ABSTRACT

Title of Thesis:	AEROTROPOLIS: AN AIRPORT AS A DRIVER OF ECONOMIC AND URBAN DEVELOPMENT.
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In previous centuries, major transportation infrastructure has fostered economic and urban development in places where they were established. This was seen with seaports in the 18th century, Railways in the 19th century, and highways in the 20th century. An emergence of a similar pattern is being witnessed this century as airports have evolved from being just transportation hubs, to drivers of business location and commercial development within and outside its boundaries.

Traditionally airports have been located in the outskirts of cities where real estate is cheap and is close enough not to be a tedious commute, but far enough from urban centers to mitigate noise pollution. However, the paradigm has shifted and the "Aerotropolis" urban format has emerged.

An Aerotropolis is a type of city where an airport is its central node, and its land use, road network, and economy are planned around this airport. Today, speed and accessibility are the new benchmark and airports are a nexus to a global stream of commerce and trade. Does this make it an ideal incentive for new urban development?

AEROTROPOLIS: AN AIRPORT AS A DRIVER OF ECONOMIC AND URBAN DEVELOPMENT

by

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Dedication

To my Parents.

Table of Contents

List of Figures

Chapter 1: Introduction

As seen with European and American Cities, transportation, and transportation planning have always been pivotal in the location of urban settlements, and in the shaping of their urban forms. In recent times, cities and other developments of smaller scales have been springing up around airports, and growing outwards of it. John D. Kasarda claims that this fifth wave of transport induced urban development is what will determine the success of businesses and the quality of life of individuals in the 21st Century. Herein is an extensive exploration of the veracity of this narrative, with a close look at precedents in which this urban model has been successful, and how they were planned. This thesis aspires to address the following questions:

- Why do airports incentivize urban development, and what characteristic(s) of the airport make the development successful?
- How does an airport city morph into an aerotropolis?
- What are the design and planning criteria of an Aerotropolis?
- How should the design scale and structure of an airport city affect its adjoining aerotropolis?
- Should the impacts of airports affect the design of adjoining aerotropoli?

Chapter 2: City Airports to Airport Cities

History of Airport development

In the past century, airports have evolved as drastically as aircrafts themselves. In the earliest stages of aviation, airplanes took off and landed on grassy fields where the planes landed at any angle that afforded them the most favorable wind direction. This evolved to bare open fields which later featured distinctive buildings to accommodate aircrafts for repairs and buildings to shelter waiting passengers. Eventually, paved taxiways and runways were used in lieu of these fields and ornate terminals, hangars and control towers replaced said buildings.[1]

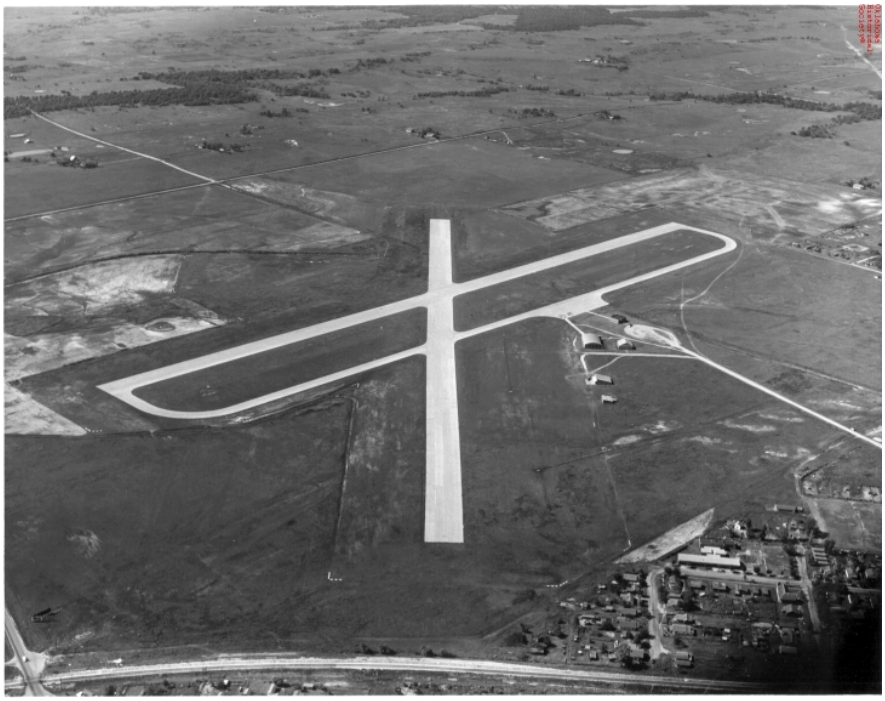

Fig. 1: Holdenville Municipal Airport, 1949 (Source: Oklahoma Historical Society)

[1] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

The history of airport development serves as the only link between Urban history and aviation history if there is any at all. Aviation journeys typically begin and terminate at airports, making it a light at the end of the tunnel. This strong importance placed on airports as a "light at the end of the tunnel" soon spilled over into the city hence creating a relationship between them in the minds of its users. Between the start of the 19th century and mid 19th century, a large portion of all international travel was limited to water or rail transportation. This made rail roads and seaports serve as primary nodes in cities. However, subsequent to the first world war and creation of larger and more reliable aircrafts in the 1920's air transportation became the preferred means of transporting people and cargo between distant locations. This had profound effect on the way people lived.[2]

The creation of the Douglas DC-3 heralded the first commercial flights between major metropolitan areas. This new development, however, did not alter the size, design, or layout of airports at the time. It was owed to the fact that airports were almost exclusively for the affluent in the society, this stagnated tangible changes in airports for a long time until more modern aircrafts were developed.[3]

The second world war was instrumental in the prosperity of an already burgeoning aviation industry. Not only did the start of the war lead to the construction of multiple airports, the end of the war also saw a large influx of military pilots who

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[2] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

[3] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

had come out of service, and a surplus of military aircrafts previously used in the war became available. A rise in the number of pilots and aircrafts needed for the war was responsible for the new airport construction in that time. More pilots, and more planes meant more pilots requiring training and more planes requiring hangars, and the solution was bigger airports. In the "European Recovery Program", civil aviation continued to develop and evolve further than it did during the war.[4]

Soon enough, airports needed to be reconstructed according to the needs of modern aviation and new larger aircrafts, and also because air travel gained popularity in use. The first part of airports that were subject to this change were runways. Advanced aircrafts required more takeoff and landing distances, and more durable paving materials on the runways.

The construction of two runways with advanced design strategies also gained popularity, this was typically done to mitigate the effects of crosswinds on the aircrafts. Continually increasing demand on air travel led to commensurate increases in the airport's facilities and provision of services to process passengers. Before long non-aeronautical services such as Restaurants, and duty-free shops got constructed within airports, birthing the "Airport City".[5]

As far back as 1939, airports were also used as places for leisure activity. This was seen in airports like La Guardia that at the time only processed 3000 passengers

[4] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

[5] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

daily, but received about 7000 additional visitors, amounting to 250,000 annually. Berlins airport also received about 750,000 yearly visitors with a roof top restaurant at its passenger terminal that sat 3000. The design of these airports, especially prewar airports was indicative of them doubling as social centers.

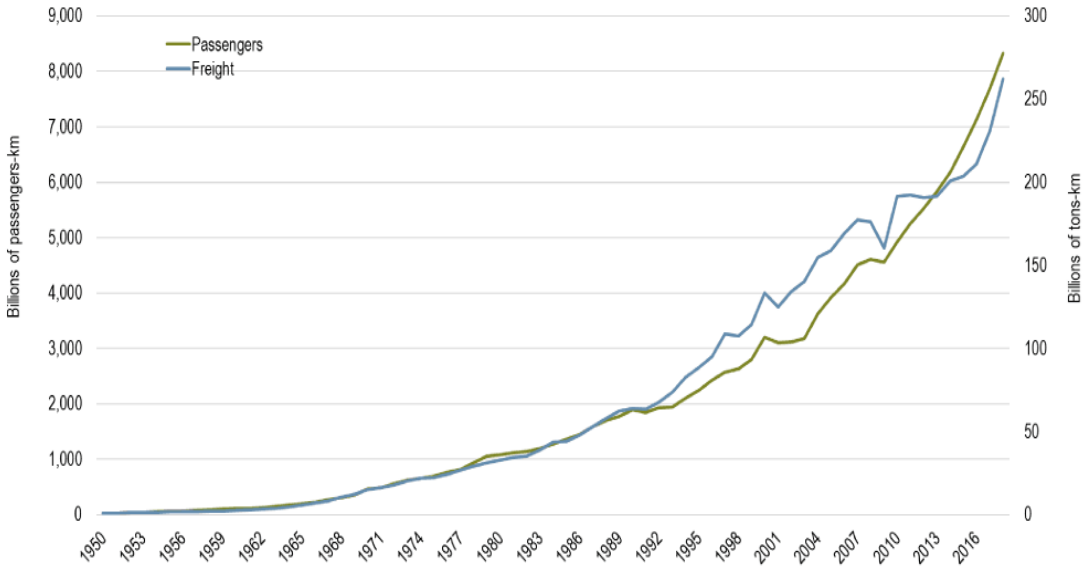

Fig 2: World air travel and air freight 1950-2016 (Source: Airlines for America)

Airports were subject to further development following the advent of jet engines. Jet engines required airports to consider advanced fuel supply systems, fuel farms, and even larger, more geometric runways and taxi ways in their design. This however led to poorer air quality around airports. Boeings introduction of the Boeing 747-100 in 1970 had a major impact on air terminal design. This was an aircraft two to three times the size of the aircraft's terminals had been used to.[6] Larger maneuvering areas, larger stands, and increased separation between gates were

[6] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

required as such. The introduction of the Boeing 777-200 in later years also spurred discussions of weather FAA airport design regulations need to be revisited.

The Airbus A380 was major milestone in aviation, it is currently the largest commercial aircraft and can sit 525-853 passengers its effects on airports can be seen worldwide, a prime example being the Dubai international airport whose third terminal was designed to accommodate only A380's. Since the introduction of this aircraft in 2007 till today, only 25 airports across the globe can accommodate the jumbo jet, but a lot more are making plans for upgrades to accommodate it
The deregulation of air travel in 1978 caused a surge in air travel, especially among Americans from 205 million in 1975 to 638 million by the year 2000.[7]

[7] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

Evolution of Airport Cities

The term Airport City refers to the infrastructure within the fence of the airport, and this includes aeronautic facilities like runways, terminals, hangars, apron, and in recent time, no-aeronautic facilities like retail, offices, hotels, chapels, museums etc. The portion of the airport determines where these facilities will be located, it is a question of whether it will Airside, or Landside.[8]

Airport Cities have been formed differently, while some were planned from its inception, many have been formed organically in response to: New business practices, Airport Land availability, increasing demands of air travelers, need for higher airport revenue, Improved ground transportation, Commercial real estate opportunities. In recent times, airports provide and serve many of the commercial functions a typical city does, thereby shifting the paradigm from a City Airport to an Airport City.[9]

[8] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

[9] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Factors Affecting Airport Development

Over the years, several factors especially advancement in aviation technology have influenced how airports have been designed and developed, however, contrary to what was earlier discussed, advancement in aircraft technology has slowly lost its influence on airport design and development in more recent years and the paradigm has shifted to political and economic development.[10] A case in point can be seen in Europe where airports were used as "Shop windows" for the state in conjunction with the national carrier. This changed, and other major changes were witnessed in airports across Europe following the privatization of the British Airport Authority and many other airports across the continent. Between 1975 and 2014, the major factors influencing airport development include:

- Threat of terrorism and unlawful acts.
- Privatization of Airports.
- Deregulation of air transport.
- Increased environmental impacts around Airports.
- Growth of local carriers.

According to the RAND-MIPT Terrorism database, there have been 225 attacks on civilian aircrafts or airports since 1980 one third (75) of which were attacks on airports and the other 150 were on aircrafts.[11]

[10] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

[11] "RAND Database of Worldwide Terrorism Incidents." 2020. *RAND Corporation*. Accessed April 18. https://www.rand.org/nsrd/projects/terrorism-incidents.html.

The 75 attacks on airports yielded 76 casualties compared to a staggering 4280 casualties yielded by the attacks on civilian aircrafts.[12] The 9/11 attack on the world trade center exaggerates this number, if it was excluded the total casualties would amount to 1400, about 20 times the total recorded at airports. Portable explosives have been the deadliest and most preferred means of terrorist attacks in the United states, a close second is the use of firearms. In light of these facts, subsequent changes have been made to airports in a bid to eliminate the possibility of such occurrence. Some major steps in this direction have been the separation of arriving and departing passengers, and the use of explosives detecting equipment around the airport.

The Airline Deregulation act of 1978 signed into law by President Jimmy Carter was put in place to amend the historic Federal Aviation Act of 1958. At the time, the Civil Aeronautics Board (CAB) was an Administrative agency that had a duty of "protecting the industry from itself" by instituting price controls, route controls and other limitations to inhibit competition between airlines. It caused a limited and ordered growth of the airline industry, and with the mid 1970's approaching, these restrictions soon seemed unreasonable hence the need for a deregulation. The new provisions of the deregulation act liberated US airlines from the economic regulations which had previously controlled it for decades and as a result, dramatic growth was witnessed in the industry.[13]

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[12] Kazda, Antonin, and Robert E. Caves. 2015. *Airport Design and Operation*. Bingley: Emerald.

[13] Newmyer, David. 1990. "The Impact of Deregulation on Airports: An International Perspective." *The Journal of Aviation/Aerospace Education and Research*1 (1).

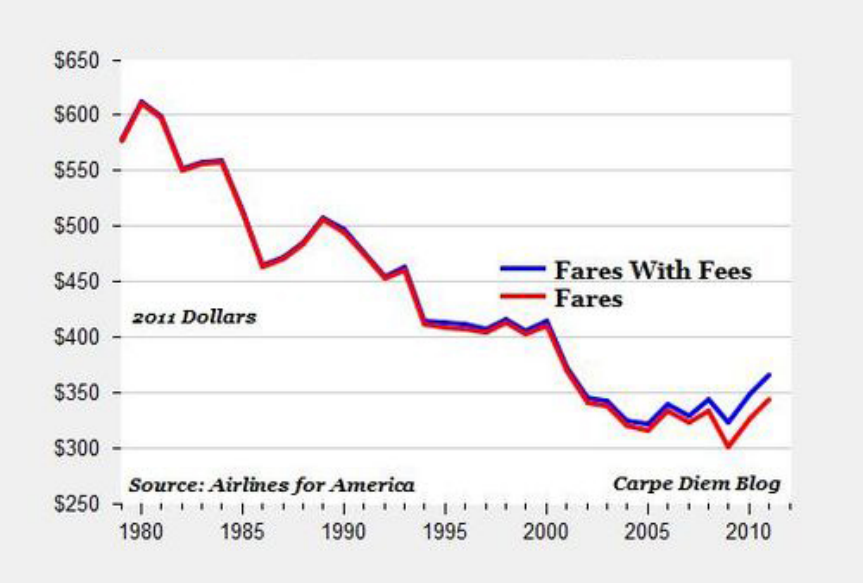

Fig 3: Average round-trip US Domestic Airfares Inflation-Adjusted 2011 (Source: Airlines for America)

Between 1978 and 1988, departing passengers increased by 66%, airline employment increased by 46%, population of passengers who had never travelled shrunk from 70% to 20%, and number of large air carriers doubled. Airports were not excluded from the effects of this deregulation. Most notably, it gave room for airlines to adopt the "Hub and Spoke" strategy at airports where the airlines bring in multiple flights into a hub airport multiple times daily, switch passengers during a layover period, and the flights depart back along the spokes. This caused significantly increased traffic at hub airports, causing the need for a reevaluation of the design strategies of such airports.[14]

[14] Federal Aviation Administration. (1989). *FAA aviation forecasts fiscal years 1989-2000.* Washington DC.

Privatization of airports was first seen in Britain back in 1986, and as other economies followed suit, it had a significant impact on the way airports were financed. It has mostly been a success, although some affirm that it has made airport operations focus more on profitability, resulting in a loss of focus on the efficiency of ground to air transport transition.[15] There are different ways in which airports can be privatized, they include:

- Share Flotation.
- Concession.
- Project Finance Privatization (Discussed further in Chapter 5)
- Management contract.
- Trade Sell.

Though these methods of privatization have varying effects on how airports are developed, they share common aims, some of which are:

- Development of competitive advantage, and efficiency in operations.
- Profit driven management and marketing techniques.
- Full or partial elimination of government financial involvement.
- Accessibility to private investments.
- Conversion of governments role from owner to regulator.

These efforts have yielded tangible improvements in airport operations and services available to passengers and other users, leading to an improvement in use, profitability, and development of airports. The benefits of this model have

[15] Augustyniak, Wojciech. 2009. "Impact of Privatization on Airport Performance: Analysis of Polish and British Airports."

surmounted its shortcomings over the years. However insignificant they may be, they need to be taken into account, they include:

1. Increased Aeronautical fees.
2. Less consideration of non-operational issues like maintenance of social justice, and environmental impact.

Since privatization of airports became commonplace, there has been a surge in environmental impacts around airports. Environmental impacts have been the adverse effects of airports despite their huge socioeconomic benefits. A need to mitigate these adverse effects in future airport developments have been of increasing priority seeing that an increase in air travel and cargo demand will only increase development activity.[16] The main burdens airports pose on the environment are: Emissions and environmental Capacity, Noise, Land utilization, Waste and congestion. These environmental concerns have infuriated communities and also caused them to frown upon airport expansion. So much so that it has resulted in the cancelation or halting of major airport expansions, a case in point being the cancelation of a planned additional runway at London Heathrow. Some steps have been utilized to make communities and environmental activists more receptive of airport expansion plans, they include:

- Regulations
- Involving communities in the design of plans to control the burdens
- Monitoring and publishing of reports
- Study of environmental burdens airports pose, and planning for further growth

[16] Augustyniak, Wojciech. 2009. "Impact of Privatization on Airport Performance: Analysis of Polish and British Airports."

Airport Master planning

The capacity of many big European airports was maxed out subsequent to the rapid growth of the aviation industry in the 80's. The continual increase in demand for air travel and freight has incentivized the expansion of airport facilities. Following the 1992 ECAC transport ministers conference, all states were required to develop ground infrastructure and identify the factors limiting the airports capacity. This agreement was met in order to ensure an easy and swift capacity increase in the future if need be. A systematic approach to this task was the best option, and it was by determining the capacity of the airport's components individually i.e. the Runway, taxi system and apron configuration, parking lots, service roads, cargo terminal, passenger terminal, ground access to airports, Hangars. The outcome of this study is a proposed layout of the airports facilities which sets the foundation for the master planning of the airport. [17]

An airport masterplan is an exhaustive study on the airports and addresses short to long term plans for airport development. Studies that address large scale revisions to the existing plan "Master Plans", while smaller scale studies intended to make changes to a portion of the existing plan are called "Master Plan Updates". The major difference in both is the level of detail and scope of the study, however, both studies are required to have the following components:

[17] "Change 2 to AC 150/5070-6B, Airport Master Plans, January ..." 2020. Accessed March 19. https://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5070-6B-Change-2-Consolidated.pdf.

1. Pre-planning – This is an inchoate stage in the process, and it involves request for proposal, Selection of Consultant and Consultant contract negotiation, design development, determination of needs, and application for funding of study.
2. Public Involvement – Subsequent to the signing of the contract by the consultants, a public involvement program should be initiated to document the challenges of all stakeholders.
3. Environmental Considerations – An understanding of the environmental regulations and requirements needed to proceed with the development is necessary.
4. Existing Conditions – An inventory of all existing data relevant to the study.
5. Aviation Forecasts – Forecasts of long-term and short-term aviation demands.
6. Facility Requirements – determine the airports ability to handle the forecasted demand with its existing facilities. Also determine the level of demand that could trigger the need for additions to the facilities.
7. Alternatives Development and Evaluation – Explore alternative options to meet the projected facility requirements subsequent to increased demand.
8. Airport Layout plans: This is a pivotal product of a master plan. It is a set of drawings that graphically represent the development plans of an airport. Additional drawings might be used in conjunction with this depending on the size of the project.
9. Facilities Implementation Plan – This summarizes the recommended improvements and its cost implications

10. Financial Feasibility Analysis – This involves the identification of the financial plan for the airport, a description of its implementation strategy, and its feasibility.[18]

Master plan studies should be tailored according to the needs of the airport. All elements of the master plan study are not required to be emphasized to same degree in all airports, but emphasis should be placed according to its relevance in the subject airport.

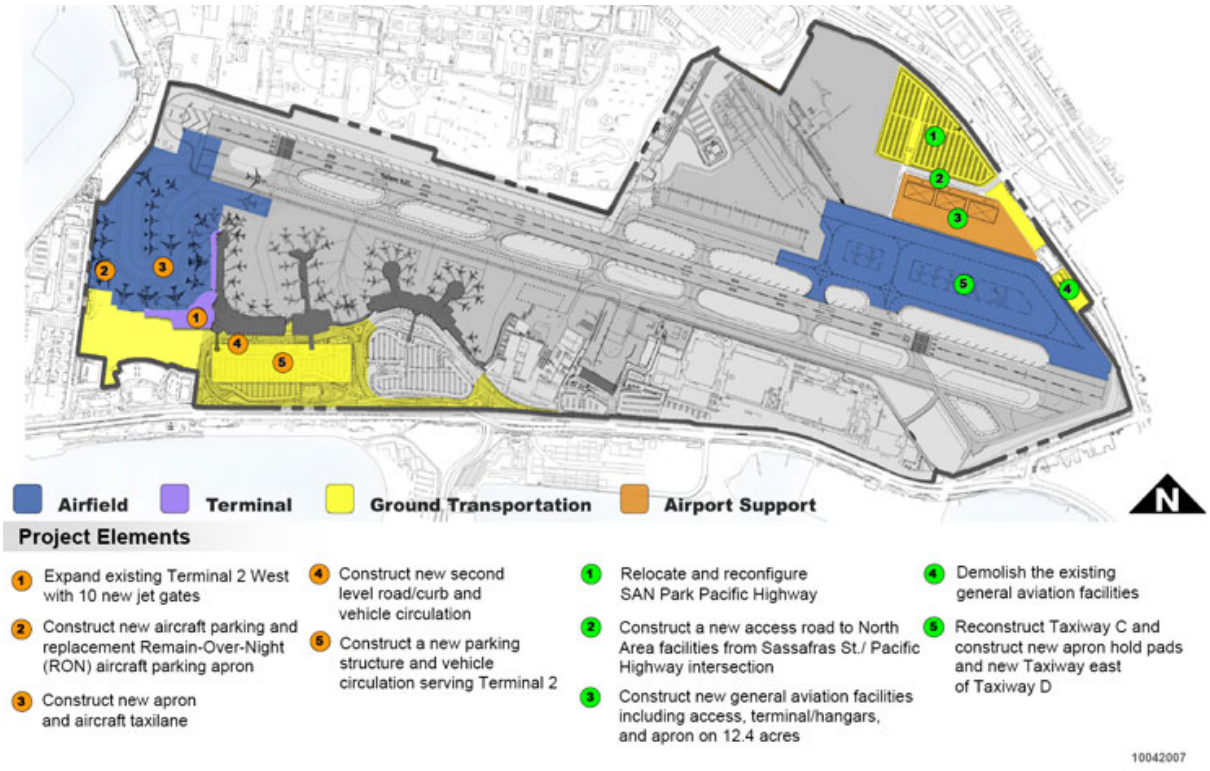

Fig. 4: San Diego International Airport Master Plan (Source: San Diego International Airport)

[18] "Change 2 to AC 150/5070-6B, Airport Master Plans, January ..." 2020. Accessed March 19. https://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5070-6B-Change-2-Consolidated.pdf.

Airport City Drivers

The availability of land and ground transportation infrastructure has caused airport cities to evolve with varying spatial forms. This evolution can also be linked to four basic drivers, which include:

- The need to magnify revenue through non-aeronautical sources, in order to compete globally, and be of better service to its users.
- The pursuit of cheap, and accessible land by the commercial sector.
- Surge in transfer passenger and cargo traffic in airports.
- Airports as an engine for business development in airport area.[19]

Aeronautic and non-aeronautic activities in airport cities can be categorized into three main categories based on their relation to air traffic.

- Core-aeronautical activities: These activities include those which contribute to the functional operation of the airport, directly servicing the airports primary functions. Examples include flight catering services, aircraft fueling activities, air traffic control, baggage claim operations, etc.
- Airport-related activities: This includes activities which indirectly support passenger traffic, and cargo, such as retail, hotels, exhibition shops, etc.
- Airport-oriented activities: Such activities/facilities chose to be located in or around the airport due to what it hopes to benefit from proximity to it, and its effective accessibility. Major factors for the location of such services are the

[19] Kasarda, John D. 2016. "Aerotropolis: Airports as the New City Center." *Airport Cities: The Evolution*.

price of land and accessibility, less importance is placed on air traffic when locating such services.[20]

Another factor which drives the development of airport cities is the airport boundaries. The boundaries of many airports were put in place several years ago, which often inhibits further expansion of airports to form airport cities. The most common commercial activities in these within airport cities include golf courses; factory outlet stores; convention and exhibition centers; business offices; hotels and accommodation; recreation and fitness; currency exchanges and banks; and restaurants.[21]

Employment has also been a driver of this model, with employment growth in airport areas surpassing that of broader metropolitan area in which these airports are located. That being said, these commercial developments are often a response to the needs of employees, and could include food services, health services, educational services, housing, etc. An example of which is seen at Frankfurt international airport. This is an airport city which is revitalizing itself, and its local economy along with it. It covers 5683-acres of land and caters to 70 million passengers yearly. The development of logistic and business centers is underway due to the surge in demand of such commercial facilities.

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[20] Karsada, John D. 2010. "Airport Cities and the Aerotropolis: The Way Forward." *Global Airport Cities*.

[21] Kasarda, John D. 2016. "Aerotropolis: Airports as the New City Center." *Airport Cities: The Evolution*.

The airport city currently features 500 plus companies which employ a total of 70,000 workers in the area. All this, and Its efficient and well-connected surface transportation system has led to it being a global business center.[22]

[22] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Airports as Corporate Headquarters

Corporate headquarters were initially restricted to central business districts in the downtown areas of cities. That, however, is no longer the case, as office services are being made available at airports, featuring meeting rooms; computer rooms; advanced telecommunication systems, etc. Terminal D, at Dallas-Fort Worth International airport, and Detroit Metro's McNamara terminal embody this holistically. They have hotels in which business professionals pour in to meet for important decision making, and other business purposes. Sheraton hotel in Amsterdam's Schiphol, Hilton hotel at Frankfurt, and Sofitel at Heathrow are some of the most famous places for conducting business activities in their respective countries.

Airport cities in Asia are taking this practice to another level. Hong Kong International airport delivered the world's largest commercial lounge which features a 15,000 Square feet business center which supports as much as 300 users, featuring meeting rooms, private workstations, video conferencing stations, etc. In today's fast paced economy, the value such developments offer its users is rapid global connectivity. As a result of this, many major airport cities now surpass the downtowns of many metropolitan districts in supply of office space and even employment.

Chapter 3: Rise of the Aerotropolis

Concept of Aerotropolis

Since the days of the Roman Empire, transportation has been a major tool with which urban form and development have been shaped. Said transportation-induced urban development was witnessed in 5 overlapping waves in the United States. The first major cities in the nation – Boston, New York – were established around seaports. The subsequent wave of urban development occurred along river and canal networks that spurred the Industrial revolution – Pittsburgh, Buffalo. Railroads lent inland areas within the country to manufacturing and trade, which led to an emergence of distribution centers, and factories at rail hubs.[23] This was the nation's third wave of transportation induced urban development. The fourth wave was set in motion by a new dependence on automobiles for the transportation of people and goods. This led to the development of industrial parks, commercial centers, suburban malls as far as 50 miles from a city's center due to the availability of beltways, expressways, and interstate highways. The ongoing fifth wave involves airports facilitating urban growth, which was heralded by the availability of large aircrafts, accelerated globalization, and time-based competition between businesses.

Futurist, Alvin Toffler claimed that at the beginning of the 21st Century, a primary law that would determine competitive success is "Survival of the Fastest".[24]

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[23] Kasarda, John D. 2000. "Aerotropolis: Airport-Driven Urban Development." *ULI on the Future: Cities in the 21st Century*, September.

[24] Kasarda, John D. 2000. "Aerotropolis: Airport-Driven Urban Development." *ULI on the Future: Cities in the 21st Century*, September.

Production of high-quality goods at competitive prices would be necessary, but insufficient for surmounting competition. The veracity of this claim was witnessed in the 1990's as the most successful companies relied heavily on information technology and high-speed transportation to conduct business effectively. Flexible production systems in conjunction with information systems which connected companies to their customers and suppliers concurrently mitigated production cycles, thereby creating more value. Speed and agility have an increased relevance to the new economy, to which air commerce is rapidly becoming its cornerstone.[25]

In response to the economy's novel need for speed, agility, and reliability, clusters and corridors of airport centered businesses have begun emerging within 15 to 20 miles of airports, hence the gradual formation of the Aerotropolis.[26]

"*An aerotropolis is an urban complex whose layout, infrastructure and economy are centered on an airport. Analogous in shape to the traditional metropolis made up of a central city and its ring of commuter-heavy suburbs, the aerotropolis consists of an airport city core and outlying corridors and clusters of aviation-linked businesses and associated residential developments".*[27]

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[25] Kasarda, John D. 2000. "Logistics & the Rise of the Aerotropolis." *ULI on the Future: Cities in the 21st Century*, September.

[26] Kasarda, John D. 2000. "Aerotropolis: Airport-Driven Urban Development." *ULI on the Future: Cities in the 21st Century*, September.

[27] Kasarda, John D., and Greg Lindsay. 2011. *Aerotropolis: The Way Well Live Next*. New York: Farrar, Straus and Giroux.

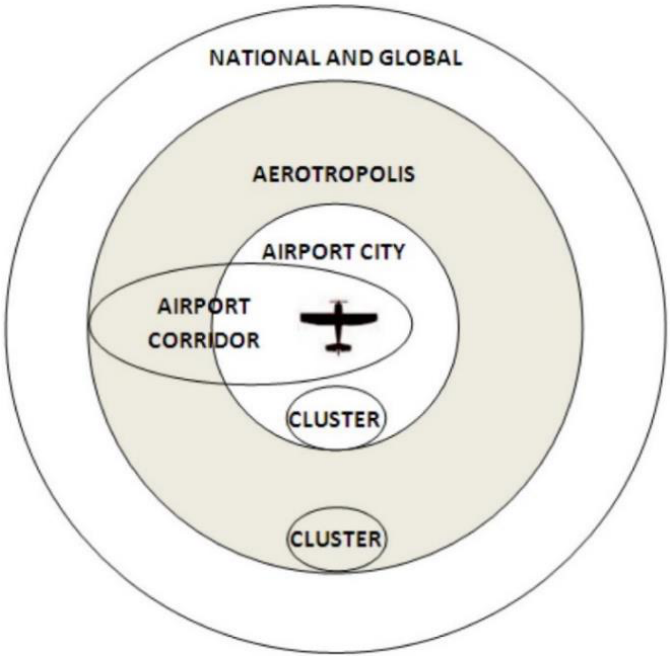

Fig. 5: Airport Centered Urban Development (Source: Mauro José Aguiar Peneda)

In 1939, the term aerotropolis was first used by an artist named Nicholas DeSantis, after presenting an imaginary drawing featuring an airport on a skyscraper's roof top in the city center. At the time the desire to integrate an airport with its city was noticeable, although the trend had been emerging since the inchoate phases of civil aviation. Airport designers sought to integrate the airport with its adjacent city, using the infrastructure to spur the development of communities around it. European architects in the 1920's and 1930's also suggested the establishment of connections between airports and existing building types, including train stations, amusement parks, and exhibition halls.[28] Decades later, John D. Kasarda revisited this partially explored idea while analyzing airport driven economic development.

[28] Kasarda, John D. 2000. "Aerotropolis: Airport-Driven Urban Development." *ULI on the Future: Cities in the 21st Century*, September.

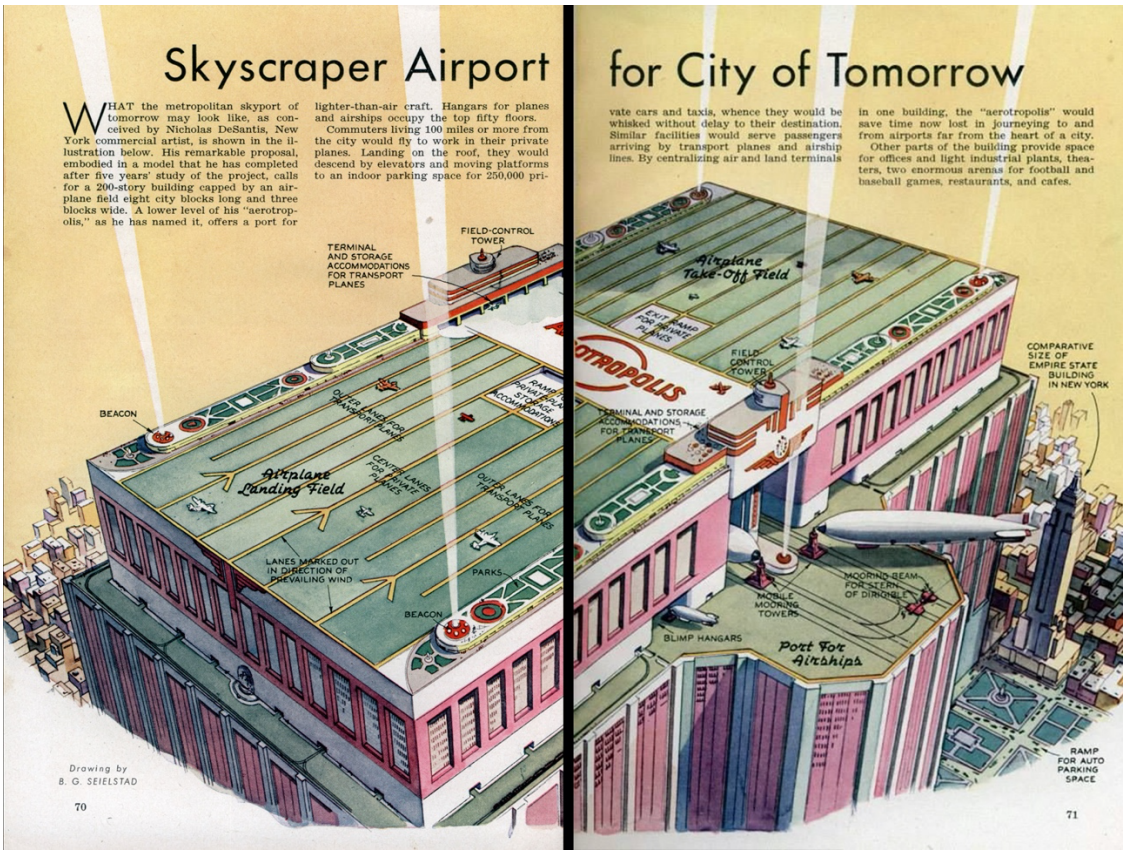

Fig. 6: Skyscraper Airport for city of tomorrow, Nicholas DeSantis 1939. (Source: Intellectual Urbanism)

The aerotropolis's primary value is that it affords businesses quick and effective connectivity on a large scale. High-tech and business service sector firms typical to the aerotropolis are often heavily reliant on partners, suppliers, and customers located far away from their metropolitan region. Time is also a currency and not merely a cost for such firms. The aerotropolis is invaluable to such firms seeing that it helps them by cutting costs, increasing productivity and market reach by

affording them rapid long-distance accessibility. Granting them a competitive advantage in the global market.[29]

Aerotropoli typically consists of spatial and functional forms. Its spatial form comprises of aviation-oriented businesses, and its related supportive developments – Residential developments, Storage, etc. – clustered around airports, and outward along its connecting corridors, generating conspicuous physical features. Its functional form, on the other hand, consists of a diffuse airport-integrated economic region whose businesses, through the airport, are linked to distant partners, customers, and suppliers as they are to those within their region.[30]

Just like any metropolis, the desirability of an aerotropolis as a place to live or work is contingent on exemplary planning, which informs development. The development of aerotropoli has mostly been organic, often resulting in economic inefficiency and unsustainable growth. The planning model of the aerotropolis lends itself as a solution to sporadic airport area development and its consequential negative effects.[31]

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[29] Kasarda, John D. 2020. "Time-Based Competition & Industrial Location in the Fast Century." *Counselors of Real Estate*. Accessed March 10.
[30] Kasarda, John D. 2015. "Welcome to Aerotropolis, the City of the Future." *New Perspectives Quarterly*32 (3): 43–45.

[31] Kasarda, John D., and Greg Lindsay. 2011. *Aerotropolis: The Way Well Live Next*. New York: Farrar, Straus and Giroux.

Planning an effective Aerotropolis

Given the liberalization of trade policies, and opening of new markets internationally, commercial aviation, and airport-centric developments (Aerotropolis developments) have been expanding accordingly. The planning principles to which the success of this urban model is contingent on intends to sustain its primary objective, economies of speed, while also boosting aviation-facilitated trade in goods and services through the improvement of connectivity in the airport's hinterlands, mobility of people and goods, and land use. The overarching objective is to improve the efficiency in daily operations and reduce costs by integrating the aerotropolis' surface transportation planning with commercial planning. This makes the airport and its surrounding business regions more competitive.[32]

Analogous to how the internet moves information quickly is how the aerotropolis intends to move people and goods quickly around the world, giving it the term "Physical Internet". With the routers of said physical internet being airports which also serve as a global – local interface for people and product movement. This multifaceted role airports play makes it an attraction for businesses, and an economic catalyst, as they not only attract, but also grow aviation-facilitated firms.[33]

[32] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

[33] Kasarda, John D. 2015. "Welcome to Aerotropolis, the City of the Future." *New Perspectives Quarterly*32 (3): 43–45.

Fig. 7: Aviation's Global Physical Internet (59,036 routes in 2012) (Source: Airline Route Mapper & UNC Kenan Institute)

The backbone of an aerotropolis is composed of three independent elements, its spatial elements which includes aviation-facilitated businesses; and its related residential developments concentrated around the airport and around its connecting corridors. The functional elements consist of the spatial elements, businesses and businesspeople close to, or far from the airport, who are highly dependent on accessibility to distant suppliers and or partners.[34] The connectivity elements comprise of air routes, rail systems, and other ground transportation infrastructure that afford the aerotropolis internal and external connectivity.

[34] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

Collectively, the spatial, functional, and connectivity elements constitute the framework of an aerotropolis upon which development efficiency, mobility efficiency, and investment efficiency within the aerotropolis rely.[35] For mobility efficiency to be attained, transportation infrastructure is required to be planned such that it facilitates the movement of people and goods within and beyond the aerotropolis. Investment efficiency requires the commercial facilities within the aerotropolis respond to the local economic and real estate demand. Development efficiency requires the facilities be located such that the land parcels they are located upon are put to their best possible use.[36]

Spatial Evolution Patterns

An aerotropolis is a component of a larger regional spatial development which leverages an airports geographic location and metropolitan spatial evolution to establish a more coherent and profitable development around the airport. Two major land use patterns govern aerotropolis planners, one engenders the growth of the airport, while the other engenders urban development. With increasing levels of cargo and passenger traffic, airport cities grow as new facilities are required to accommodate the increasing volumes of activity, and when threshold levels are reached, locating these facilities further away from cargo and passenger terminals become more profitable. A case in point is Schiphol Airport.

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[35] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

[36] Charles, Michael B., Paul Barnes, Neal Ryan, and Julia Clayton. 2007. "Airport Futures: Towards a Critique of the Aerotropolis Model." *Futures*39 (9): 1009–28.

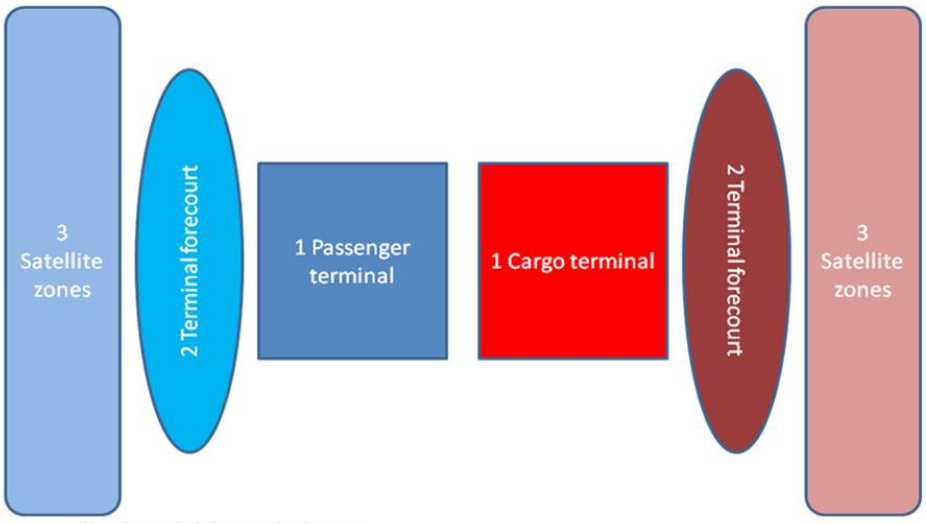

Fig. 8: Airport cities outward growth from terminals (Source: John D. Kasarda)

Airport cities and aerotropolis grow differently, and could be dependent on regional economic conditions, airport area land availability, passenger volume, ground transportation infrastructure, cargo demand, and other factors. Consequently, the location and mix of commercial facilities within the aerotropolis vary just as its urban/physical form. Seeing that an aerotropolis is a part of a larger spatial entity, the path of urban development has a pronounced effect on the nature, timing, and process of aerotropolis development.[37]

The primary "location decision" making factor for firms is proximity to airport, however, some other factors are considered, one of which is the need for access to the metropolitan areas business district. This results in the development of office buildings, and business parks along highway corridors, linking the business

[37] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

districts to the airport thus affording occupants access to the airport, and the necessary provisions the business district offers their business processes. Developments often "vault" across the airport to its sparsely occupied land on its other side, there by accelerating the aerotropolis' outward growth pattern. A case in point of the aforementioned phenomenon is Washington Dulles.[38]

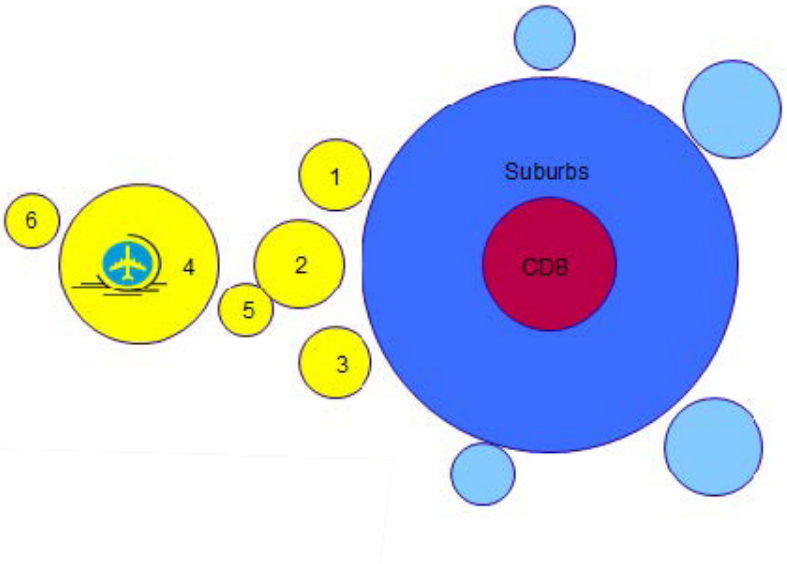

Fig. 9: Cities Grow out to Airports as their transport exerts pull (Source: John D. Kasarda)

Newer airports are predominantly located at the edge of metropolitan areas, as the older ones closer to the downtown are replaced due to their inability to expand. This results in travel time constraints from the downtown area to the airport particularly if the airport opens prior to the construction of its connecting transportation infrastructure.

[38] Freestone, Robert, and Douglas Baker. 2011. "Spatial Planning Models of Airport-Driven Urban Development." *Journal of Planning Literature*26 (3): 263–79.

Such process often leads to the organic formation of the aerotropolis around the new airport as seen in Incheon international airport, and Guangzhou airport.[39] This process of aerotropolis formation is summarized as follows:

- The airport leaves the City
- The city follows the airport
- The airport becomes an airport city
- An aerotropolis emerges from the airport city

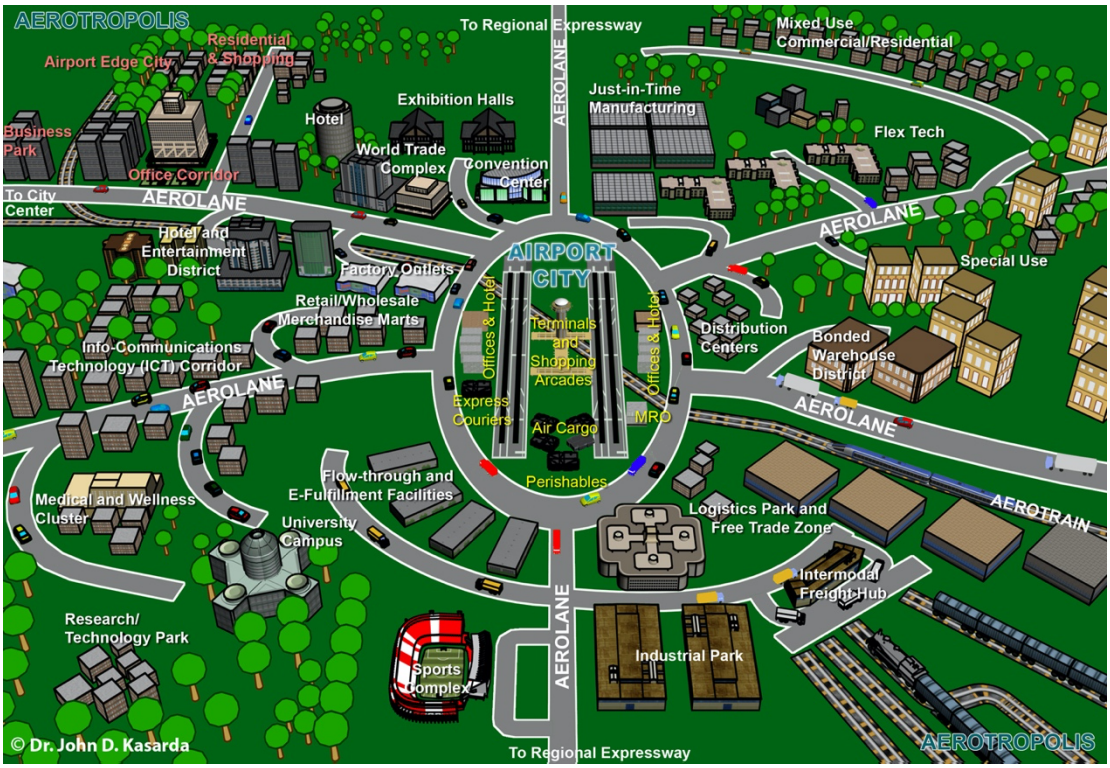

Fig. 10: Aerotropolis Schematic with Airport City Core (Source: John D. Kasarda)

[39] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

Commercial facilities which constitute the greater aerotropolis cannot and should not be planned independently of the greater metropolitan region's land use and development patterns. Likewise, commercial facility investments by aerotropolis developers cannot be planned independently of potentially competitive ones in the region, as such uncoordinated investment/developments can split demand thus rendering them unviable. Coordinating the land use and transportation planning within the aerotropolis with that of the greater metropolitan region is also necessary for an efficient aerotropolis development.[40]

Land-Use and Transportation Planning

According to the Federal Aviation Administration of the United States, an aerotropolis is *"a planned and coordinated multimodal freight and passenger transportation network that provides efficient, sustainable, and intermodal connectivity to a defined region of economic significance centered around a major airport"* the above definition implies the pertinence of transportation planning to the development of an aerotropolis.[41] Aerotropolis transportation planning also encompasses the design of systems for safe and efficient personal and cargo mobility.

Passenger and cargo journeys neither begin nor terminate at airport terminals, this magnifies the importance of integrated surface transportation planning near the

[40] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

[41] "H.R. 2006 (114th): Aerotropolis Act of 2015." 2015. *GovTrack.us*. April 23. https://www.govtrack.us/congress/bills/114/hr2006/text.

airport. With respect to time and money, getting to and from the airport is often costly for passengers and cargo, and so is the negotiation of airport related hinderances, hence the creation of "Last mile" costs. Last mile cost refers to the effort, time, and money needed for passengers and cargo to get to or from the airport. This cost is often substantial in comparison with the insignificant cost of flying an extra mile, a successful aerotropolis should therefore mitigate this cost in order to improve operational efficiencies and attract investments.

The success of firms using air freight is increasingly dependent on adequate ground transportation (surface accessibility), and such is the case for passenger travel as road congestion around airports and its downtown areas increasingly create unsuitable air travel conditions. For moderate length journeys, such as from Chicago's downtown to New York City's downtown, passengers often spend more than half the total travel time stuck in traffic congestion on the freeway, the airport terminal, or even the airport taxiway. Such obstacles impede the competitiveness of firms, and the economic and residential appeal of the city, hence the prioritization of total time and cost of the journey in decisions of location and mode of travel. This reality exposes the shortcomings of airport area planning, and why it should be addressed in the planning of an aerotropolis. In conclusion, the integration of airport planning, land use planning, and surface transportation planning are important for an effective aesthetic and operational outcome in the aerotropolis for the following reasons:

- The airport and its immediate environment (aerotropolis) set an enduring first and last impression of many travelers to the airport area, its surrounding municipalities, and the greater metropolitan region.
- Given the intermodal nature of air journeys, the first and last legs often occur via surface transportation, which affects the total travel time and cost.
- Just as docks did for ships, and railroad terminals did for trains in earlier eras, surface transportation anchors air cargo and other airport-facilitated businesses by acting as spatial organizers.[42]

Well planned aerotropoli have endless outcomes, most notable of which are the higher property values, increased attraction of passengers and cargo, expansion of high-tech manufacturing and business services, thereby improving the economy, the establishment of economic growth nodes which attract new investments, and counter sprawl by its contribution to densifying land uses[43]. Despite the organic and sprawling nature of many aerotropoli today, the future of aerotropolis planning can be significantly improved with strategic urban and infrastructure planning some of which are summarized below:

- Establishment of expressways, and express trains dedicated to efficiently connecting airports to major businesses and residential nodes.

[42] Kasarda, John D. 2020. "Aerotropolis: Business Mobility and Urban Competitiveness ..."

[43] Kasarda, John D., and Stephen J. Appold. 2014. "Planning a Competitive Aerotropolis." *Advances in Airline Economics the Economics of International Airline Transport*, September, 281–308.

- The addition of “truck-only” lanes, and the improvement of interchanges to abate congestion.
- Travel time rather than travel distance between key nodes should be of greater importance in aerotropolis planning.
- The proximity of businesses to the airport should be determined by their frequency of use, hence improving time cost.
- Activities such as trucking, manufacturing, warehousing and storage should be spatially segregated from residential, and white-collar service facilities, as well as airport passenger flows.
- Developments which are Noise and emission sensitive should be located outside the noise and emission zones of the airport.
- Cluster development with green spaces between clusters should be encouraged along airport corridors, as opposed to strip development.
- Thematic architectural features should be used for placemaking and wayfinding.
- Communities which house airport area workers should be developed such that their commute is short, and a sense of neighborhood is established.[44]

[44] Kasarda, John D. 2020. “Aerotropolis: Business Mobility and Urban Competitiveness ...”

Aerotropolis Drivers

An aerotropolis is often considered as the physical incarnation of globalization, given its reflection of major increases in long-haul aircrafts which connect enterprises, products, and people worldwide.[45] Additionally, it reflects new supply chain processes in which components are manufactured in multiple different countries, assembled in another, and then distributed to many others.

The ever-burgeoning world tourism economy has also facilitated aerotropolis development, so has the expansion of aviation intensive business services such as management consulting, finance, and marketing all of whose firms are increasingly gravitating towards airport areas. Another major driver of the aerotropolis is this new consumer age, in which consumers have grown less patient to receive products ordered online from distant locations.[46]

Despite the extreme relevance of the internet in the modern age, it is incapable of physically moving goods, therefore making such businesses "contact sports". Hence the importance of airport-linked enterprise networks (aerotropolis). This is evident in the supply chain of iPhones, seeing that an order from Germany, Africa, or the U.S requires the flight of an aircraft from China. The outcome being that airport and their immediate areas (aerotropolis) serve as magnets for such time critical businesses. Currently, over 33% of the total world trade value is transported by air,

[45] Kasarda, John D. 2020. "Aerotropolis: Business Mobility and Urban Competitiveness ..."

[46] Charles, Michael B., Paul Barnes, Neal Ryan, and Julia Clayton. 2007. "Airport Futures: Towards a Critique of the Aerotropolis Model." *Futures*39 (9): 1009–28.

this will only increase given the certainty of global income increase, and economic shift to lighter, and compact high value products such as medical instruments, aerospace components, specialty perishables, microelectronics, and pharmaceuticals.[47]

Fig 11: Apple iPhone global supply chain (Source: John D. Kasarda)

[47] Kasarda, John D. 2020. "Aerotropolis: Business Mobility and Urban Competitiveness ..."

Chapter 4: Challenges of Aerotropoli.

The aerotropolis model, is coveted by businesses, financial institutions, governments, and other sectors pertinent to a country's economy. Champions of this urban form and its many other beneficiaries deem it attractive, sustainable, and globally competitive citing its tourism attraction, employment generation, and value appreciation of surrounding communities. It is however not without its shortcomings. These challenges can broadly be categorized into environmental, social, and technological. Aircraft noise, ground noise, and air quality are some major environmental challenges posed by aerotropolis schemes, while a major social challenge is community exclusion. All of which will be discussed herein.

Aircraft Noise

In the fledgling years of aviation, the sparsely populated air space gave little concerns about noise. In the 1950's however, the rapid expansion of civil aviation was heralded by the advent of the first jet aircraft which had a noisy engine. This led to a skyrocketed discomfort in neighboring communities which motivated the formation of opposing groups to airport expansion. This garnered the attention of various governments. Specific noise limits were put in place in several airports around the world. Consequentially, in 1971 the International Civil Aviation Organization (ICAO) promoted noise certification standards in airports globally.[48]

[48] "'Sustainable Airport Areas, Guidelines for Decision Makers' Is Launched in Île-De-France." 2020. *Metropolis*. Accessed April. https://www.metropolis.org/news/sustainable-airport-areas-guidelines-decision-makers-launched-ile-de-france.

The increasingly stringent noise certification standards encouraged the development of noise-abated technologies for aircrafts, which have been responsible for a significant portion of the noise reduction in airports and their hinterlands today. This is, however, still a critical issue today as aircraft noise is the primary hinderance for airports reaching their full operational capacity. Some best practices for addressing this issue are listed below;

- Sound insulation to mitigate noise in residential areas.
- Compensation measures.
- Adoption of Noise exposure plan.
- Implementation of noise mitigation programs.[49]

The adoption of a noise exposure plan has proven to be one of the more effective measures over the years. Its successful implementation was seen around Charles De' Gaulle international airport in France, where four zones of noise exposure (very high, high, moderate, and low) were delineated around the airport, and its surrounding land uses were planned accordingly. Housing could not be located in the Very high exposure zones, but could be located in the moderate to low exposure zones, etc.[50]

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[49] "'Sustainable Airport Areas, Guidelines for Decision Makers' Is Launched in Île-De-France." 2020. *Metropolis*. Accessed April. https://www.metropolis.org/news/sustainable-airport-areas-guidelines-decision-makers-launched-ile-de-france.

[50] "'Sustainable Airport Areas, Guidelines for Decision Makers' Is Launched in Île-De-France." 2020. *Metropolis*. Accessed April. https://www.metropolis.org/news/sustainable-airport-areas-guidelines-decision-makers-launched-ile-de-france.

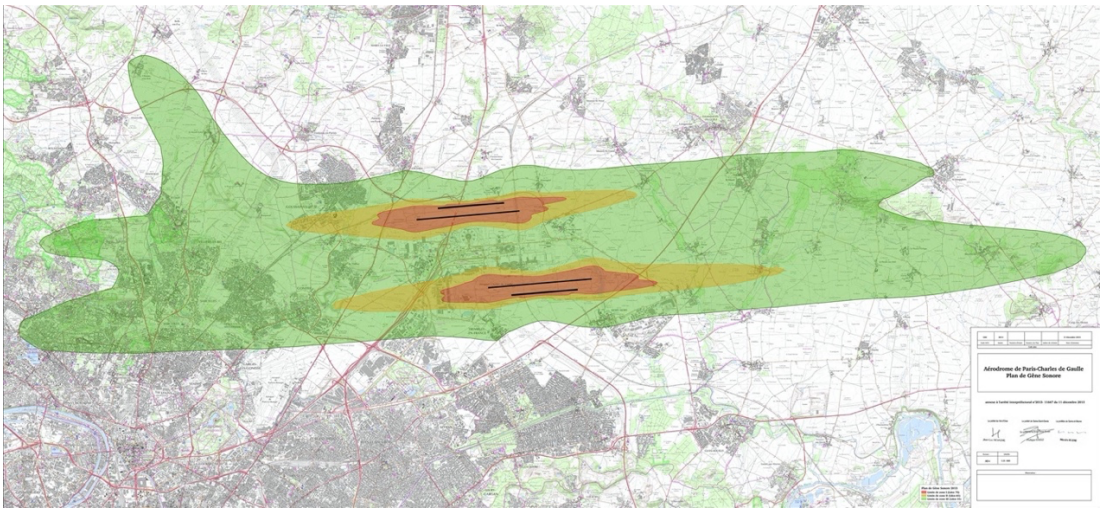

Fig. 12: Noise exposure around Charles De' Gaulle International Airport (Source: ACNUSA)

The implementation of noise mitigation technique's such as the gradual descent, and approach for aircrafts, and the routing of landing and takeoff paths away from populated areas have proven been successful over the years, with the former being ubiquitous in Europe.[51] It requires an aircraft's quick ascent to 3000ft before easing its throttle to reduce thrust and turning towards its destination, as opposed to gradually climbing to 400-800ft, reducing its thrust, and climbing further to 1000ft before turning towards its destination while continuing its ascent.[52]

[51] "'Sustainable Airport Areas, Guidelines for Decision Makers' Is Launched in Île-De-France." 2020. *Metropolis*. Accessed April. https://www.metropolis.org/news/sustainable-airport-areas-guidelines-decision-makers-launched-ile-de-france.

[52] "Aircraft Noise: A Toolkit for Managing Community Expectations." 2009, 124–26.

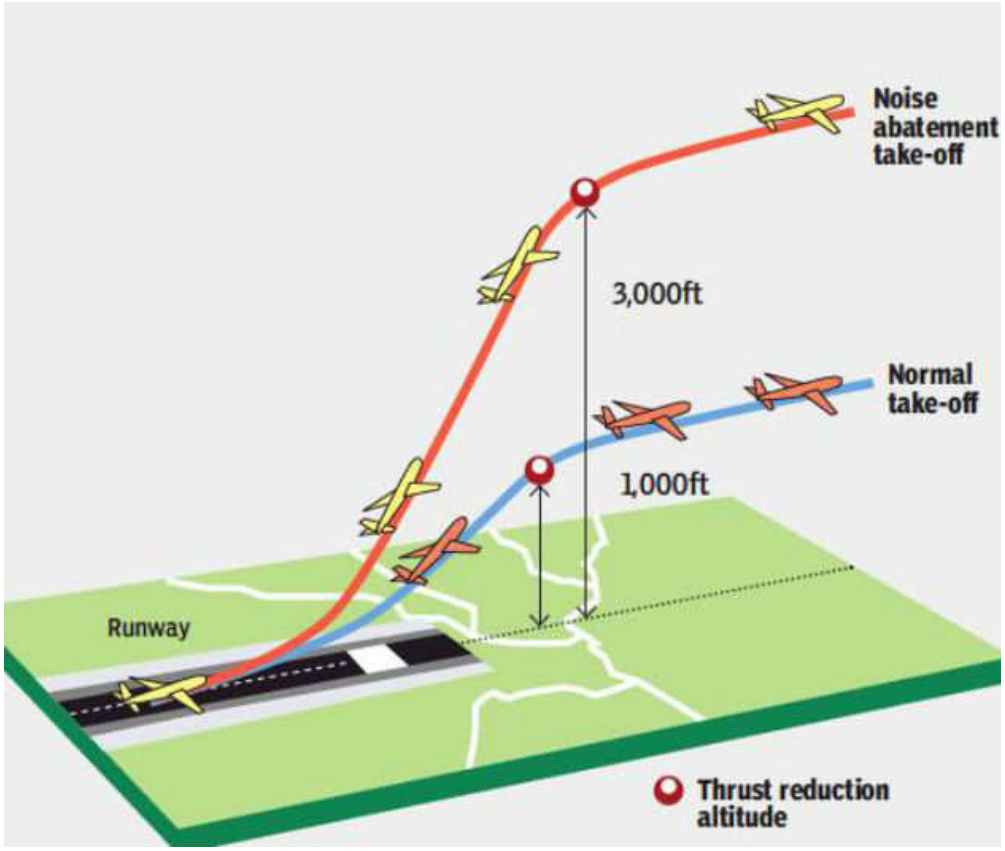

Fig. 13: Aircraft noise abatement takeoff procedure (Source: Dipankar Chanda, The times of India)

Ground Noise

In noise mitigation programs, measurements, or calculations around airport areas, ground noise is not considered, which is problematic because the affected areas are not always covered by noise zones. This has caused the emergence of concerns among citizens of airport area. Ground noise is generated by aircrafts ground operations such as taxiing, engine testing, preparing for take-off. Some other sources of ground noise include noise from Auxiliary Power Units, airfield and landside activities, ground transportation of passengers and goods.[53]

Airports around the world have implemented different policies and solutions in response to this issue. One of the most successful being the one implemented in Schiphol Airport, Netherlands. After operations began on the airport's new 5th runway, ground noise concerns grew amongst residents in the area. This was followed by technical analysis which revealed that improvement of soil absorption, and operational measures; high buildings; and a high noise barrier are potential solutions to this issue.[54] The solution which was eventually implemented was a recreational park which consisted of 150 ten feet tall pyramids of grass which formed embarkments that dispersed ground noise. They were ordered perpendicular to the

[53] "'Sustainable Airport Areas, Guidelines for Decision Makers' Is Launched in Île-De-France." 2020. *Metropolis*. Accessed April. https://www.metropolis.org/news/sustainable-airport-areas-guidelines-decision-makers-launched-ile-de-france.

[54] Hansman, Heather. 2015. "This Crazy Land Art Deflects Noise From Amsterdam's Airport." *Smithsonian.com*. Smithsonian Institution. May 27. https://www.smithsonianmag.com/innovation/crazy-land-art-deflects-noise-from-amsterdams-airport-180955398/.

sound waves for optimal results. This effective work by Ernst Chladni – an acoustician – has reduced the noise pollution by 50%.

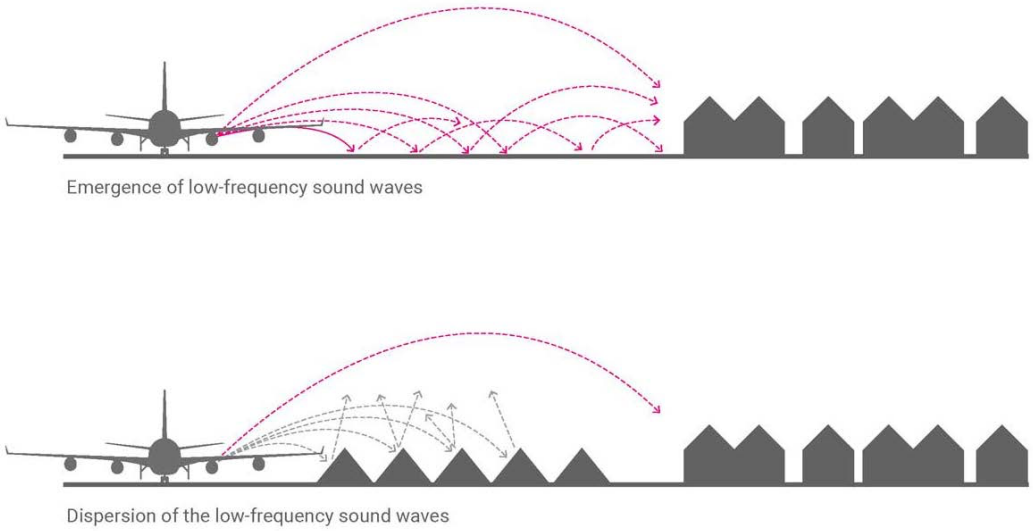

Fig. 14: Mitigation of ground noise with ridges (Source: H+N+S Architects)

Fig 15: Land Art Park Buitenschot, Schiphol Airport, Netherlands (Source: Luchtfotografie)

Air Quality

The air quality in airport hinterlands are determined by numerous factors. Its major sources include apron activities such as fueling; aircraft emissions; and ground transport. Major pollutants include Particulate matter (PM); Nitrogen oxides (NOx); Unburned hydrocarbons (UHCs); and Carbon monoxide (CO). With significant side effects including Premature mortality; respiratory diseases; cardiovascular diseases; Lung irritation and impairment; and eye infections.[55]

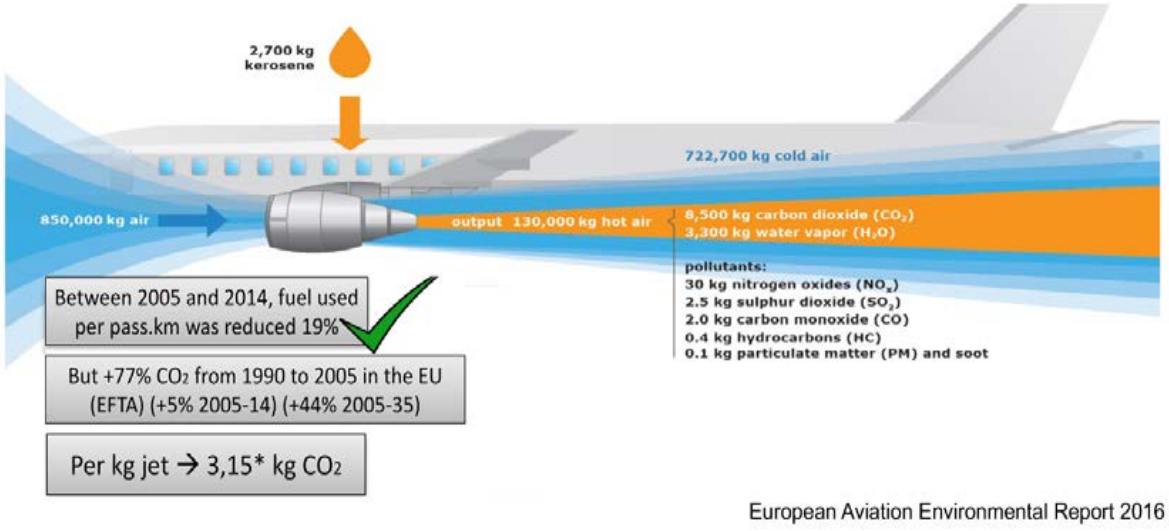

Fig 16: Emissions from a typical two-engine jet aircraft during a 1-hour flight with 150 passengers (Source: FOCA)

The enactment of air quality legislation can significantly mitigate airport, and airport area growth, aircraft emission standards have however been adopted and implemented across the globe, and the Committee on Aviation Environmental Protection (CAEP) are responsible for updating these standards, some of which

[55] "Airport Air Quality Manual." 2020. Accessed May 4. https://www.icao.int/environmental-protection/Documents/Publications/FINAL.Doc 9889.1st Edition.alltext.en.pdf.

include the U.S/European Atlantic Interoperability Initiative to Reduce Emission (AIRE) and the U.S/Australasian Asia & South Pacific Initiative to Reduce Emissions (ASPIRE). Some best practices for mitigating poor airport quality in airport areas include the following: Adopting emissions charges; reduction of pollution at source; and operational procedures to reduce emission.[56]

[56] "'Sustainable Airport Areas, Guidelines for Decision Makers' Is Launched in Île-De-France." 2020. *Metropolis*. Accessed April. https://www.metropolis.org/news/sustainable-airport-areas-guidelines-decision-makers-launched-ile-de-france.

Community Exclusion

Communities which host aerotropolis are typically excluded from the project in several ways. It undermines the objectives of building equitable and inclusive cities, given its primary objectives of anchoring business initiatives, along with the high levels of security that go along with airports. Consortiums are granted of autonomy when undertaking such projects, which takes the project further out of local residents' control. Furthermore, its facilities primarily cater to wealthy upper-class passengers and users.[57] This has allowed aerotropolis schemes to merely be seen by private investors as assets with which high returns can be generated through public-private partnerships that afford them tax breaks, and other financial incentives to mitigate their risk exposure. The use of public money in these public-private partnerships is at the expense of the same citizens who are excluded. The same practice is also seen in developing countries with high poverty rates, and other substandard economies. These projects require a large expanse of land, and proposed projects such as the one in Ethiopia, often lead to the displacement of thousands of citizens.[58]

Technological critiques claim that advancements in videoconferencing and telecommunications would subvert business travel, and perhaps leisure travel.

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[57] "Box: The 'Aerotropolis' Phenomenon – High Risk Development Thwarting SDGs." 2020. *Welcome! / Willkommen!*Accessed May 10. https://www.2030spotlight.org/en/book/1165/chapter/box-aerotropolis-phenomenon-high-risk-development-thwarting-sdgs.

[58] "Aerotropolis Alert! Airport Mega-Projects Driving Environmental Destruction Worldwide." 2017. *The Ecologist*. November 17. https://theecologist.org/2015/may/08/aerotropolis-alert-airport-mega-projects-driving-environmental-destruction-worldwide.

Other critiques of the aerotropolis scheme also claim that advancement in 3D printing technologies could also result in a reduced need for time sensitive cargo shipments, thereby extinguishing the need for airport proximity. Analysts have also claimed that high-speed rail can serve as a substitute for air travel in the future. Despite the veracity of this concern, it is somewhat without merit.[59] Improvements in telecommunications technology has been goaded by human mobility over long distances. Social networking, for instance, has caused a surge in "digital friendships" globally among individuals with aligning interests, many of whom are separated by hundreds to thousands of miles, and should any of them suggest a physical get together, air travel will surge. The same can be said about businesses, and why a permanent shift to video conferencing is unlikely.

The emergence of 3D printing promises to contain the need for printing certain products, this technology, however, has its limits and cannot be utilized with certain product types, at least for the foreseeable future. Given that the world's largest producer of high-speed rail – China – are also the world's leader in aerotropolis development, it shows that the former has no substitution effect on the latter, but in fact serves as its key component. Furthermore, high speed rail is limited to distances within 500 miles of each other making many intercontinental connections impossible, thereby narrowing its viability as a replacement of aircrafts in cargo transportation.[60]

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[59] Kasarda, John D. 2019. "Aerotropolis." *The Wiley Blackwell Encyclopedia of Urban and Regional Studies*, 1–7.

[60] Kasarda, John D. 2019. "Aerotropolis." *The Wiley Blackwell Encyclopedia of Urban and Regional Studies*, 1–7.

Chapter 5: Overview of Aerotropoli Globally.

Incheon Aerotropolis

One of the world's most audacious attempts at developing an aerotropolis is taking place around Incheon International Airport, South Korea. The core of this aerotropolis features commercial complexes whose multimodal features are consonant with that of a metropolitan center, some of which include office buildings; logistics facilities; retail developments; conference centers; exhibition centers; ICT and High-Tech assembly facilities; leisure activity centers; and a mixed-use town. Under construction is a high-speed commuter rail line which connects Seoul – The country's capital – to Incheon International airport which is 42 miles south.[61] They are however currently connected by tunnels, bridges and expressways.

[61] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Fig 17: Incheon Intl. Airport to Seoul (Source: Google earth/Author)

The 15,000-acre airport property which opened in March of 2001 is the 7th largest in Asia and is significantly larger than its counterparts around the world. With a total of 404,104 aircraft movements annually, it welcomes 71 million passengers, and processes 2.7 million tons of cargo, and its capacity has steadily grown over the years, from 25 million passengers in 2004. With its sights set on reaching a 100 million passenger capacity by 2030, the airport is undergoing a phased expansion.[62] The 15-year horizon master plan has residential, and commercial components whose evolution will occur in three phases, in order to establish a well-integrated urban development.

[62] Capa. 2016. "Seoul Incheon Airport: 49 Million Passengers in 15 Years. Well on the Way to 100 Million in 2030." *CAPA - Centre for Aviation*. CAPA - Centre for Aviation. April 4.

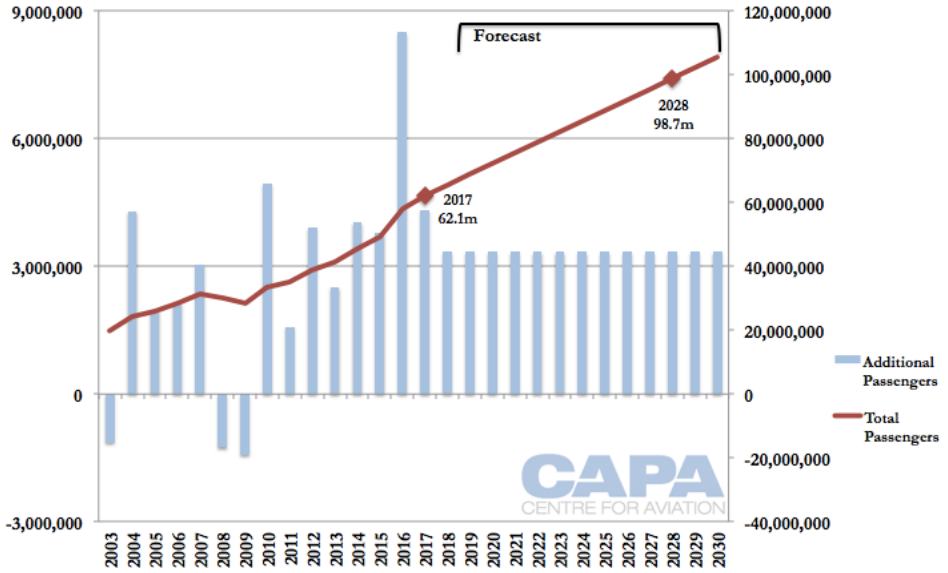

Fig. 18: Incheon International Airport Passenger traffic forecast (Source: CAPA- Center for Aviation and Airport)

Its already completed first phase is an airport support community which comprises of Logistics facilities, commercial facilities, and residential facilities which supports the airport's employees, and their families. Phase 2 which is in the pipeline involves the spatial and functional expansion of the aforementioned airport support community, transforming it into a business city. A 360-acre portion of the business city comprising of a shopping mall; two five-star hotels; a convention; and exhibition center; and four office became operational in 2008.[63]

An additional 220-acre international logistics and manufacturing zone (The Airport Free Zone) which became operational in 2006 is also under development.

[63] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

The international business center and the international logistics and manufacturing zone are planned such that it doubles in space as the passenger traffic of the airport city also doubles in the next five years.

Fig. 19: Incheon Intl. Airport to New Songdo City (Source: Google Earth/Author)

The third stage is "The International Free Trade City" which is a full-fledged aerotropolis tied together by an international free enterprise zone. The International free enterprise zone will comprehensively include three islands, all of which are connected by bridges. The overarching goal of the country is for it to be transformed into Northeast Asia's primary commercial and trading center. The entire development is being dubbed a "Pentaport"; a combination of an airport, business port, seaport, teleport, and leisure port.[64]

[64] Poon, Linda, and Linda Poon. 2019. "Songdo, South Korea's Smartest City, Is Lonely." *CityLab*. July 9. https://www.citylab.com/life/2018/06/sleepy-in-songdo-koreas-smartest-city/561374/.

The greater Incheon Aerotropolis encompasses two islands; Yeongjong Island; and Songdo Island. Yeongjong Island located around the airport, primarily houses airport-facilitated offices, hotels, exhibition and trade facilities, logistics, leisure facilities, and tourism facilities, the largest of which are a 384-acre water park; and a 250-acre $1 billion fashion island south of the airport which is planned to be Asia's fashion Mecca.[65] It will have luxury hotels, outlets, and exhibition space. Songdo Island, the second island features New Songdo City, a city created entirely on reclaimed land by New York City's Gale, and South Korea's largest steel producer in a joint venture, along with the south Korean Government.[66]

Fig. 20: Aerial View of New Songdo City (Source: KPF Architects)

[65] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

[66] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Fig. 21: New Songdo City Master Plan (Source: KPF Architects)

The project is financed by Morgan Stanley, along with several other banks. A full completion, the $30 billion, 1500 acre project will be the largest private development in the world, with over 9000 residences, including townhomes, and

condominiums; an excess of 15 million square feet of commercial and office space; a cultural center; a central park; a convention center; a golf course; a medical facility, and a school for children of expatriate workers.[67] The first phase of this project which includes 2360 homes, a 65-story trade center, a 1000 room hotel, and a 1 million square feet retail complex commenced in 2005 and was completed by the end of 2008. The South Korean government further incentivized developers by constructing a 6-lane, 7-mile bridge which connects New Songdo City directly to Incheon international Airport. The provision of this infrastructure was supplemented with generous financial incentives such as tax breaks, and tax credits throughout the region, to further incentivize development from the private sector, across this emerging aerotropolis.

Hong Kong Aerotropolis

Hong Kong International Airport is a model airport city, with an emerging aerotropolis. The 2,700-acre site of the airport was created in the 1990's partly by reclaiming land from the sea, and partly by leveling two small adjacent islands. Operations began at the $20 billion airport in July 1998, and it has an annual passenger and cargo capacity of 71.5 million passengers, and 4.8 million tons respectively, and with an 8.5% growth rate, the airport aspires to reach a passenger capacity of 100 million by the year 2030.[68]

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[67] Banai, Reza. 2016. "Viewpoint: The Aerotropolis: Urban Sustainability Perspectives from the Regional City." *Journal of Transport and Land Use*10 (1).

[68] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Delivered along with the airport was a multilane expressway, and express trains to Kowloon, and Hong Kong Island, which are 20-miles west of the airport.

Fig. 22: Hong Kong Intl. Airport to Kowloon & Hong Kong Island
(Source: Google earth/Author)

Adjacent to the airport's terminals are three commercial districts, one of which is a 70-acre district comprised of logistics facilities. Some of the logistics facilities in this district include the following: Tradeport Hong Kong Ltd.; HACTL's Super Terminal, the worlds larges free standing air-cargo facility which has a gross area of 2.7 million square feet.; Asia Air's 2 million square feet Freight terminal; a mixed-use freight-forwarding office and warehousing complex; DHL's Asia air

express hub; Cathy City – an aviation-facilitated office complex.[69] The second of the three commercial districts are a 26-acre district envisioned as an office park whose gross floor area will be about 3 million square feet. Primarily intended to attract global corporate offices, and other professionals with occupations heavily reliant on aviation.

The third district is the airport's signature development – Sky City. Sitting on 110 acres north of the airport's passenger terminal, the 10 million square feet commercial development is serviced by the airports express train. It is the core of the aerotropolis, and has been developed as a destination for trading, entertainment, shopping, working, and meeting. Its first phase which opened to the public in 2006 contains a commercial complex (sky plaza) whose lower floors contain a 300,000 square feet retail area, including a theater. Above are class A office spaces all of which have a 300,000 gross floor area. Sky City also includes Asia World Expo, a 2 million square feet exhibition center; a golf course, and a 600-room hotel. Sky City's subsequent phases will include other hotels, leisure facilities, and a business park.[70]

[69] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

[70] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Fig 23: Sky City site north of Hong Kong International Airport's terminal (Source: Google Earth/Author)

In addition to its road and rail connections to Kowloon and Hong Kong Island, this multimodal Central Business District of Hong Kong's aerotropolis is linked to the nearby Disney Theme Park by an express train and highway which also connects within five minutes to Tung Chung – a residential development for airport workers, and their families featuring churches, schools, and medical facilities. Large mixed-use residential towers have also been completed as an addition to this residential development.[71]

[71] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Jet ferries also connect Sky City to Pearl River Delta, which is located in southern coastal china. In less than 45 minutes, these jet ferries convey workers, tourists, and passengers both ways between Sky City, and important Delta locations.[72]
A similar connection to Hong Kong's mainland is also seen in the commercial district south of the airport which is linked by logistic ferries to the Deltas primary manufacturing centers, conveying finished goods both ways between the airport and the mainland.

Hong Kong International Airport is further integrated with the rest of Hong Kong, and the Delta by an expressway, rail bridge and tunnel, all of which link Hong Kong to Zhuhai and Macau on the mainland. This combination of transport systems (express/rail bridge) which is planned to connect through Lantau (the airport island) will not only magnify Sky City's role as a destination for tourists, local business professionals, and shoppers, but will also solidify this airport city's role as the multimodal hub driving the expansive Hong Kong aerotropolis.[73]

[72] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

[73] Kasarda, John D. 2008. "The Evolution of Airport Cities and the Aerotropolis." *Airport Cities: The Evolution*.

Fig. 24: Aerial View of proposed Sky City development (Source: South China Morning Post)

Chapter 6: Scale and Design Structure of an Aerotropolis

Cities are continually expanding structures which require adequate control, and planning plays a major role in either inhibiting or encouraging the city's expansion. The most important factor here being the city's scale in the development process. Planning and scale ratios are of equal importance to a city given the latter's importance to the way in which humans (the users of the city) experience it. An aerotropolis is a part of a larger regional city, and an extension of an airport city, it should therefore be scaled and designed pursuant to the regional city's urban design guidelines, and the airport city's scale. A closer look at model examples of the two major kinds of aerotropoli – Cargo leveraged aerotropolis and Passenger leveraged aerotropolis – will be used in evaluating their different scales and structures.

Cargo-Leveraged Aerotropolis

Memphis which has been known for the last three decades as America's logistics hub has been transformed to a global logistics hub with the advent of its aerotropolis. With respect to cargo traffic, the Memphis International Airport is the busiest airport in the United States. With over 4,000,000 metric tons of yearly cargo, 3,500,000 yearly passengers, and its provision of 34% of the total employment in the region, the Memphis Airport is the second busiest cargo airport in the world behind Hong Kong International Airport.[74]

[74] Ozdenerol, Esra, Anzhelika Antipova, Farid Javadnejad, and Cem Akkus. 2020. "Compatibility of Freight Transportation and Land Use in ..." Accessed May 2. https://www.memphis.edu/ifti/pdfs/cifts_compatibility_freight_transportation_land_use.pdf.

The adjoining Aerotropolis covers a 50 square mile area around the airport and extends 25 miles outwards from the center of its airport city and is also seven miles south east of the city's downtown.[75] It is a typical example of a "cargo leveraged aerotropolis" given the nature and primary use of the airport which it surrounds, and the type of businesses located within the aerotropolis. A staggering 90% of the aircraft movements at this airport are cargo related, while the average for other airports around the globe is less than 25%.

Fig. 25: Memphis Intl. Airport and Aerotropolis boundary (Source: Google Earth/Author)

[75] Banai, Reza. 2016. "Viewpoint: The Aerotropolis: Urban Sustainability Perspectives from the Regional City." *Journal of Transport and Land Use*10 (1).

The integration of the airport at this aerotropolis' center is a result of it being leveraged by the cargo transported through the airport. Had that not been the case, it would ideally be located separately from the airport, as in the Zuidas aerotropolis discussed herein. Aerotropoli which are leveraged by cargo have a somewhat different design structure from those which are primarily leveraged by passenger traffic given their relatively different requirements for successful implementation.

There is a direct correlation between the airports cargo capacity, and the aerotropolis' scale; its land use distribution; and its employment scale. Furthermore, the primary residents and users of such aerotropolis are individuals who work within the aerotropolis.[76] Like many other aerotropoli, its land use distribution is predominantly allocated to residential uses, there is however a significant allocation to industrial uses clustered around the airport unlike many other aerotropoli.

[76] Ozdenerol, Esra, Anzhelika Antipova, Farid Javadnejad, and Cem Akkus. 2020. "Compatibility of Freight Transportation and Land Use in ..." Accessed May 2. https://www.memphis.edu/ifti/pdfs/cifts_compatibility_freight_transportation_land_use.pdf.

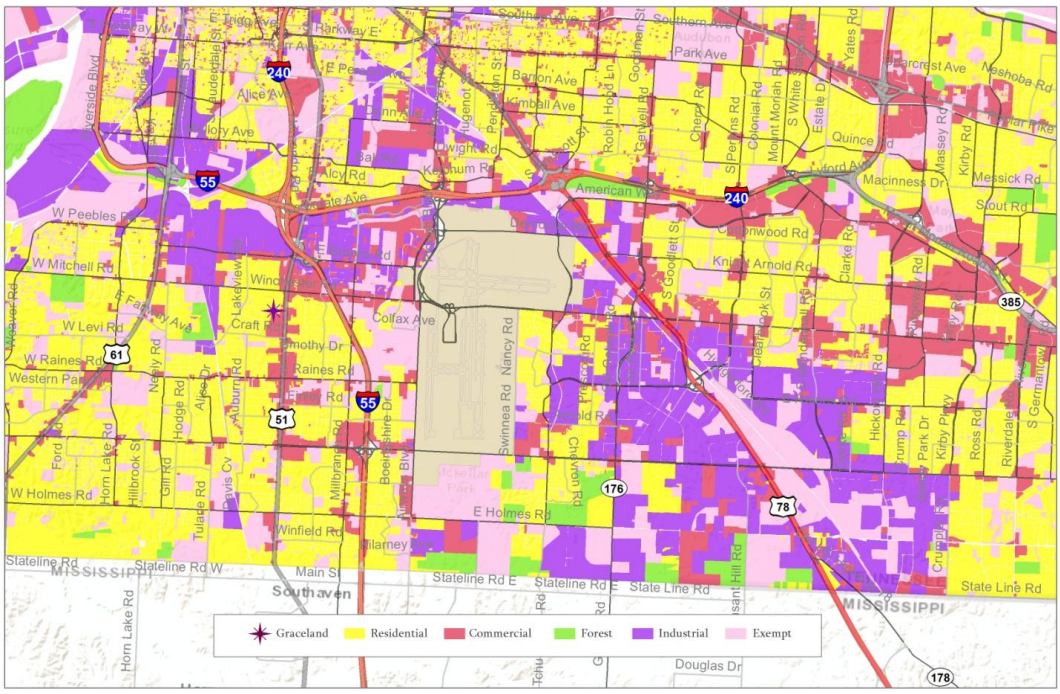

Fig. 26: Memphis Aerotropolis area land use (Source: Esra Ozdenerol)

The design structure of this aerotropolis relative to the airport's noise landscape differs from that of other aerotropoli. As rarely seen in "passenger leveraged aerotropoli", the noise land scape of the Memphis international airport overlaps the aerotropolis. This is the case in other "cargo leveraged aerotropoli" due to the fact that predominant land use in the aerotropoli (Industrial) can function effectively notwithstanding the noise generated by the airport.

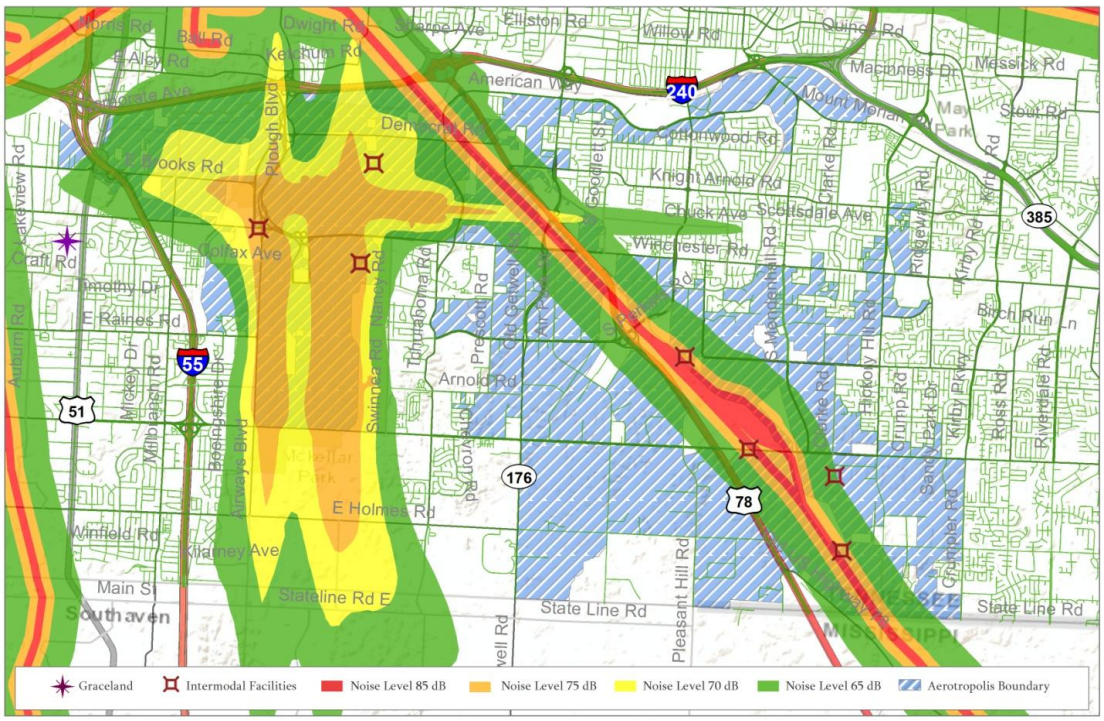

Fig. 27: Memphis Aerotropolis area noise landscape (Source: Esra Ozdenerol)

Passenger-Leveraged Aerotropolis

Amsterdam's Schiphol International Airport is the hub of the country's flagship carrier – KLM – which connects the country to 133 international destinations in 66 different countries. It is often considered the best airport in Europe, but with a yearly passenger capacity of 77.7 million; a total of 496,000 annual aircraft movements; 1.5 million tons of annual cargo; and an economic impact of $27.3 billion, it is the third busiest and most profitable airport in the continent after London Heathrow and Charles de' Gaulle international airport, Paris.[77]

Its adjoining aerotropolis, Zuidas district covers a 734-acre expanse of land, located 14 miles east of Schiphol international airport, and 2.5 miles south of Amsterdam's city center.[78] Given the passenger to cargo proportion of 93%/7% processed through the airport, its primary function is passenger travel and transfer. In response to this, the adjoining aerotropolis is a model "passenger-leveraged aerotropolis" and its land uses also indicate so.

[77] "All the Major Facts on Amsterdam Airport Schiphol." 2020. *Schiphol*. Accessed May 24. https://www.schiphol.nl/en/route-development/page/amsterdam-airport-schiphol-airport-facts/.

[78] Banai, Reza. 2016. "Viewpoint: The Aerotropolis: Urban Sustainability Perspectives from the Regional City." *Journal of Transport and Land Use*10 (1).

Fig. 28: Schiphol International Airport to Zuidas District (Source: Google earth/Author)

Its distance location from the airport is partly due to the sensitivity of some of its uses to airport noise. Such developments are ideally located outside the “very-high” and “high” intensity noise zones of airports.

The design structure, and scale of this development directly correlates with the airport’s capacity, size, and function. Of all the passengers processed annually at the airport, 36% are transfer passengers, leaving the Zuidas district to cater to the remaining 64% which actually leave the airport. Facilities such as museums, malls and theaters within airport cities serve transfer passengers, as seen at Schiphol international. From its inception in the 1970’s, the district was planned to have three main features: Excellent accessibility, A rich setting and a diversity of uses.

It currently has over 200,000 daily users which includes 25,000 permanent residents, 80,000 employees, and 30,000 students. Interestingly, its number of daily

users is consonant with that of the airport which is 212,000.[79] Suffice to say that this development was planned in accordance with the airport's capacity, which should be the case in future aerotropoli. Major law firms, financial consultancy firms and financial services firms such as ABN-AMRO and ING have opted to move their head offices here, some in the renowned world trade center, due to its accessibility to the global market. Its amenities include hotels, restaurants, bars, childcare facilities, sports centers etc. it also features several schools; which offer primary, secondary, tertiary, and vocational education.

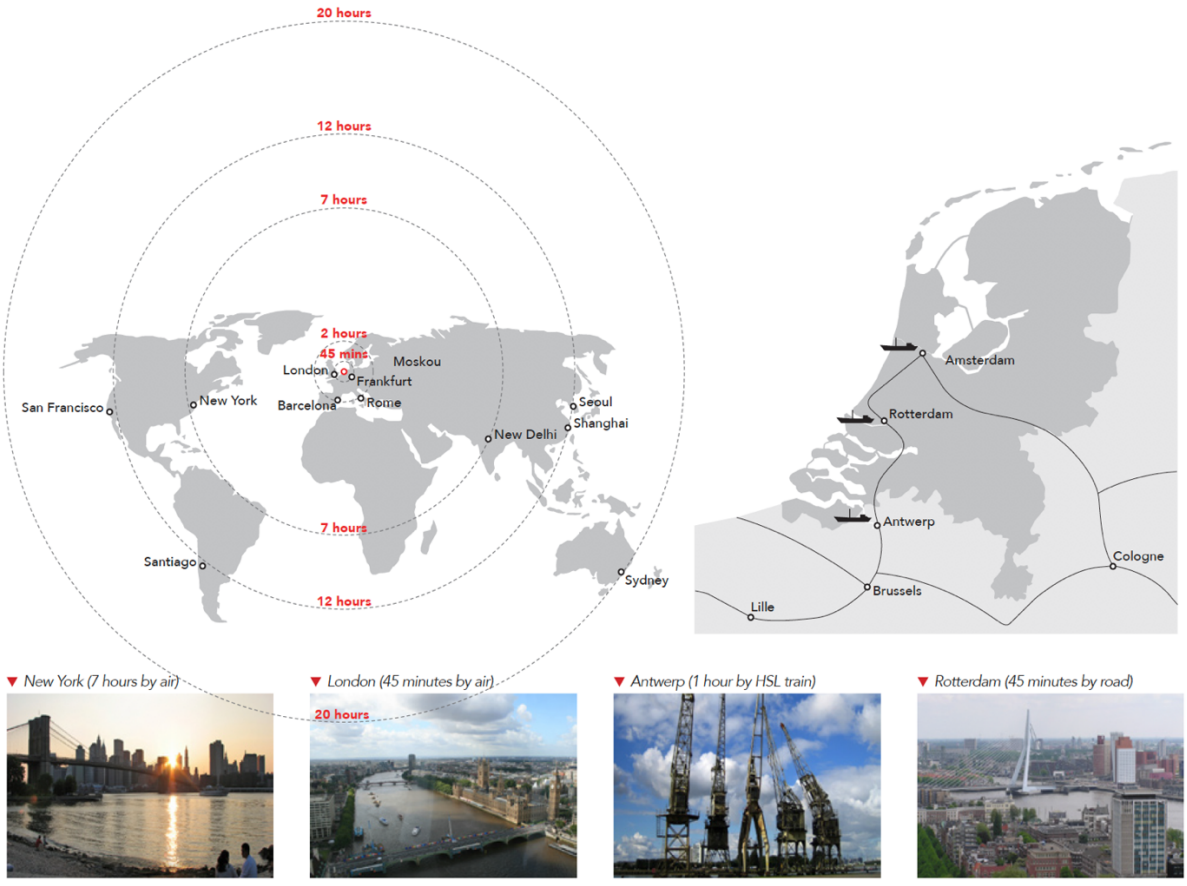

Fig. 29: Zuidas distance to major Cities (Source: Zuidas Vision, Amsterdam City Council)

[79] "Zuidas Vision ." 2009, September, 11–12.

Pursuant to its intended design framework and scale, the development has a total of 12.9 million square feet of commercial space, 9.6 million square feet of residential space, and 13.9 million square feet of public realm.[80] Its design framework comprises of the following:

- Landscape
- Urban Streets
- Open Spaces
- Water management
- Energy and other utilities

Fig. 30: Zuidas business district (Source: Google earth/Author)

[80] Zuidas Vision." 2009, September 11–12.

Chapter 7: Design Proposal

Project Summary

Fig 31: Master Plan – Full Buildout
(Source: Google Earth/Author)

This thesis is designed as a biotech and life sciences centered mixed use, urban development, located north of San Diego International Airport. The project envisions what is currently a derelict marine corps recruit depot as an Aerotropolis, whose proximity to the airport affords its inhabitants (Biotech Companies) easy access to the global market.

Currently located on the site are 12 historic buildings, all of which will be preserved and repurposed for retail uses, leaving the northern portion of the site with its historic character.

The parade ground south of the historic portion is repurposed as a large open space which extends southward into the new development, stitching both portions of the site together.

Fig 32: Existing Site Conditions
(Source: Google Earth/Author)

The goal of this thesis is to explore what benefits the aerotropolis urban model affords businesses which are heavily reliant on innovation and air travel. In that regard, this urban model also creates a "cluster effect" in which similar companies, including start-ups, are located close to each other, creating better opportunities for collaboration, and growth.

The development strategy is to have the life sciences component central to the site, and surrounded by a satellite terminal; and residential, lodging, light manufacturing, and retail uses.

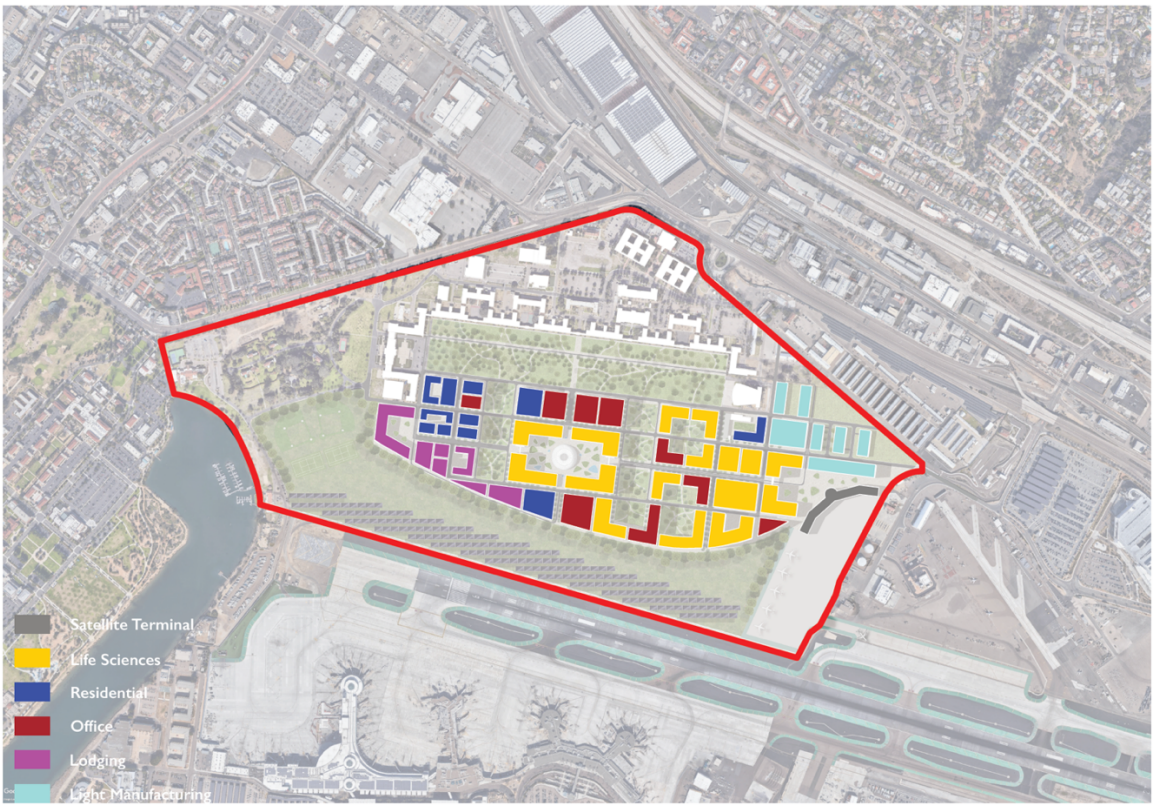

Fig 33: Site Program
(Source: Google Earth/Author)

The satellite terminal serves as a direct access point to the airport's runway from the site. Through this terminal, businesses will export products manufactured within the site. Additionally, it serves as an entry and exit point for business executives.

Phasing

Given the large scale of this project, its development will happen in the span of four phases, with each subsequent phase serving as an extension of the previous' success.

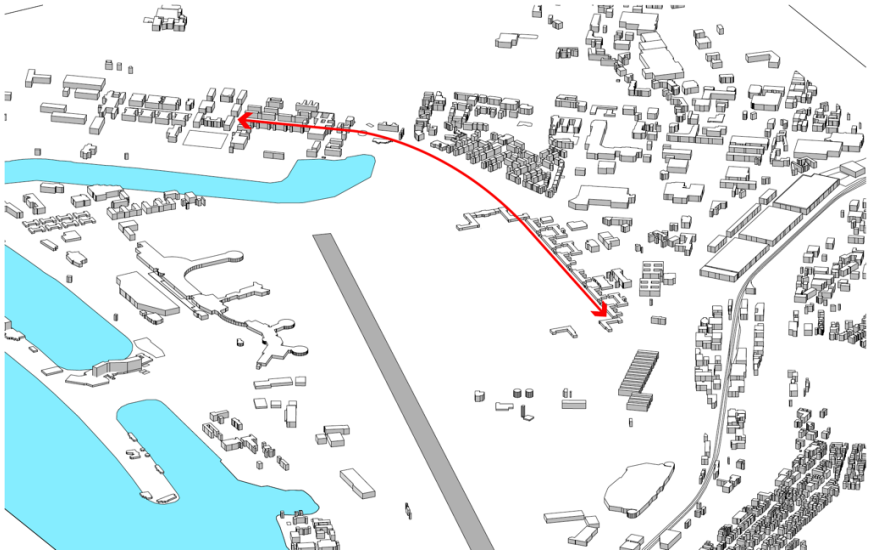

Fig 34: Phase One
(Source: Author)

In the first phase, the existing buildings on the site are demolished, and the historic buildings are repurposed as retail, extending the retail corridor at liberty station west of the subject site.

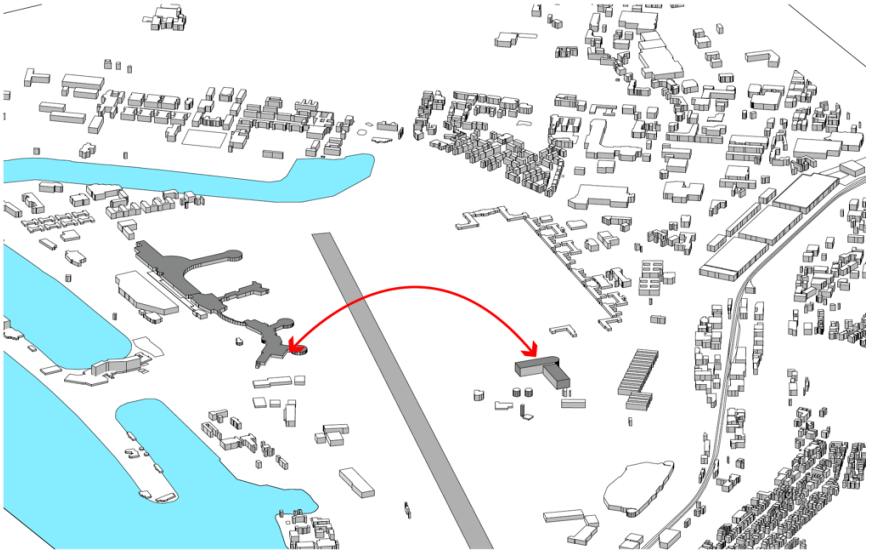

Fig 35: Phase 2A
(Source: Author)

In the second phase, the airport is extended across the runway by establishing a satellite terminal across. This bridges the gap between the new development and the airport's terminal.

Fig 36: Phase 2B
(Source: Author)

Fig 37: Phase 3
(Source: Author)

Subsequently, life sciences, light manufacturing, retail, and light manufacturing are proposed, establishing a place, and drawing activity into the area.

The third phase involves the development of the site's core and central node. This is where the anchoring life sciences buildings are located, under which an underground transit terminal will be located, connecting the entire site directly to the proposed metro station and the airport via a light rail system.

Fig 38: Phase 4
(Source: Author)

In the fourth and final phase, a supporting residential and lodging district is developed, providing a potential home for majority of the employees working within the site.

Fig 39: Rendering of Central Node
(Source: Author)

At full buildout, the core serves as an arrival space and transit point from the train station or airport onto the site. Within the central arrival space, and outside, on the ground floors of the surrounding buildings, biotech products manufactured locally are displayed to inform visitors on new scientific discovery.

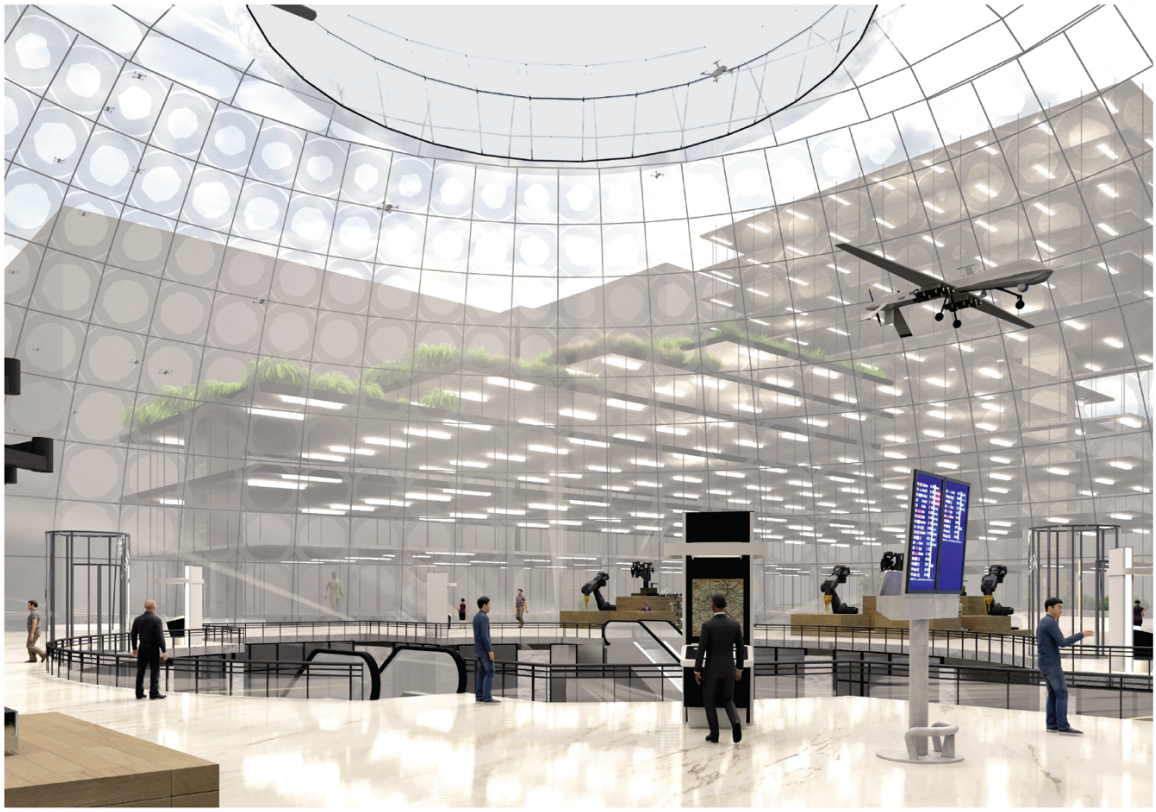

Fig 40: Rendering of Arrival Space
(Source: Author)

This extends through the central arrival space to both ends of the site, along the central spine.

This tech display corridor includes a mix of retail, enhancing the user experience from arrival till exit.

Fig 41: Rendering of Shopping Space – Transit Terminal
(Source: Author)

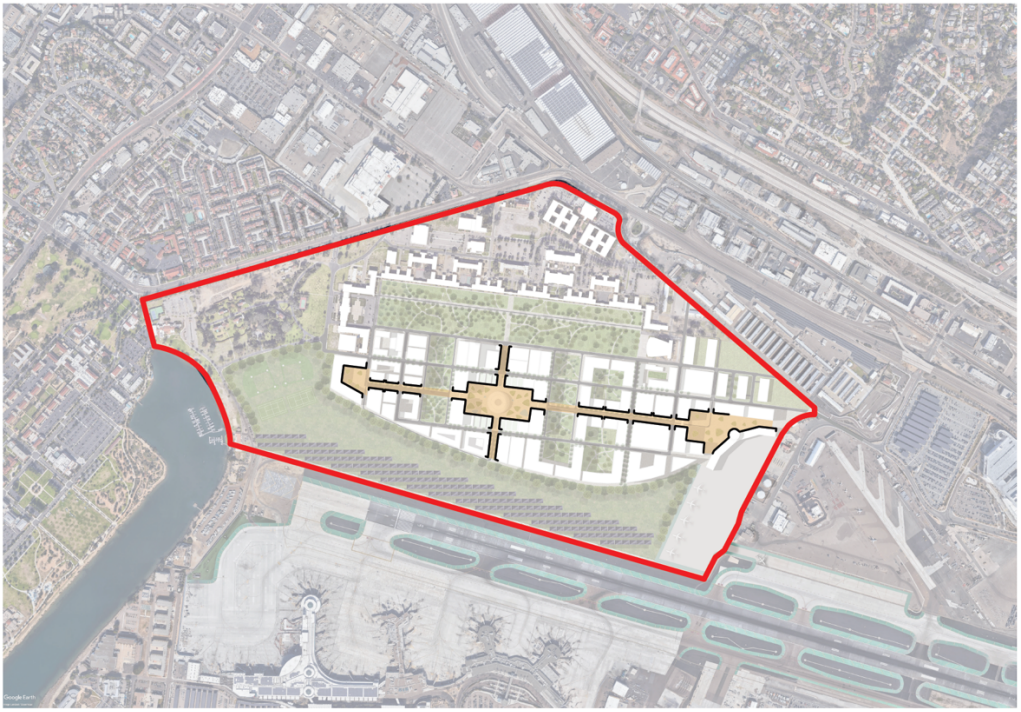

Fig 42: Retail and tech display corridor diagram
(Source: Google Earth/Author)

Central to this thesis' purpose is ease of access to resources, aiding productivity. In that regard, Life sciences buildings at the project's central node have direct access to the underground arrival terminal.

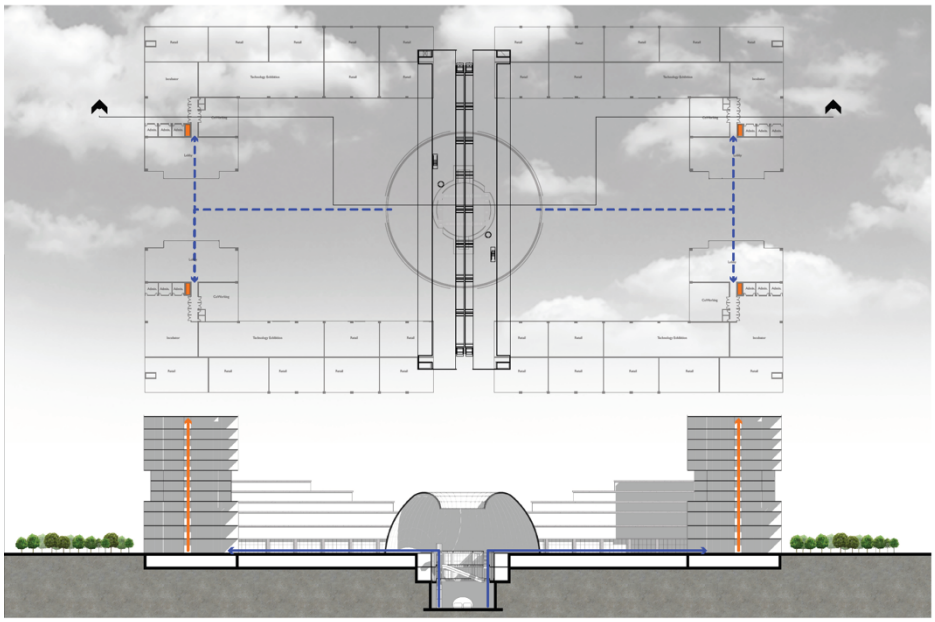

Fig 43: Latitudinal Section – Central Node
(Source: Author)

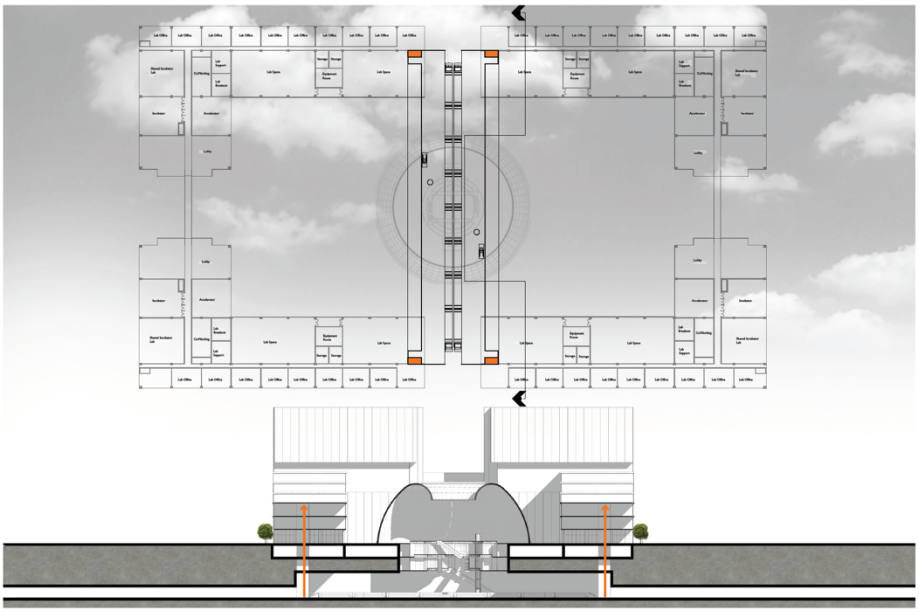

Fig 44: Longitudinal Section – Central Node
(Source: Author)

Vehicular transportation within the site is limited to one primary route connecting the site to the rest of the city, and a few secondary routes stitching the site together. Additionally, an above ground light rail system offers users the flexibility of traveling around the site quickly.

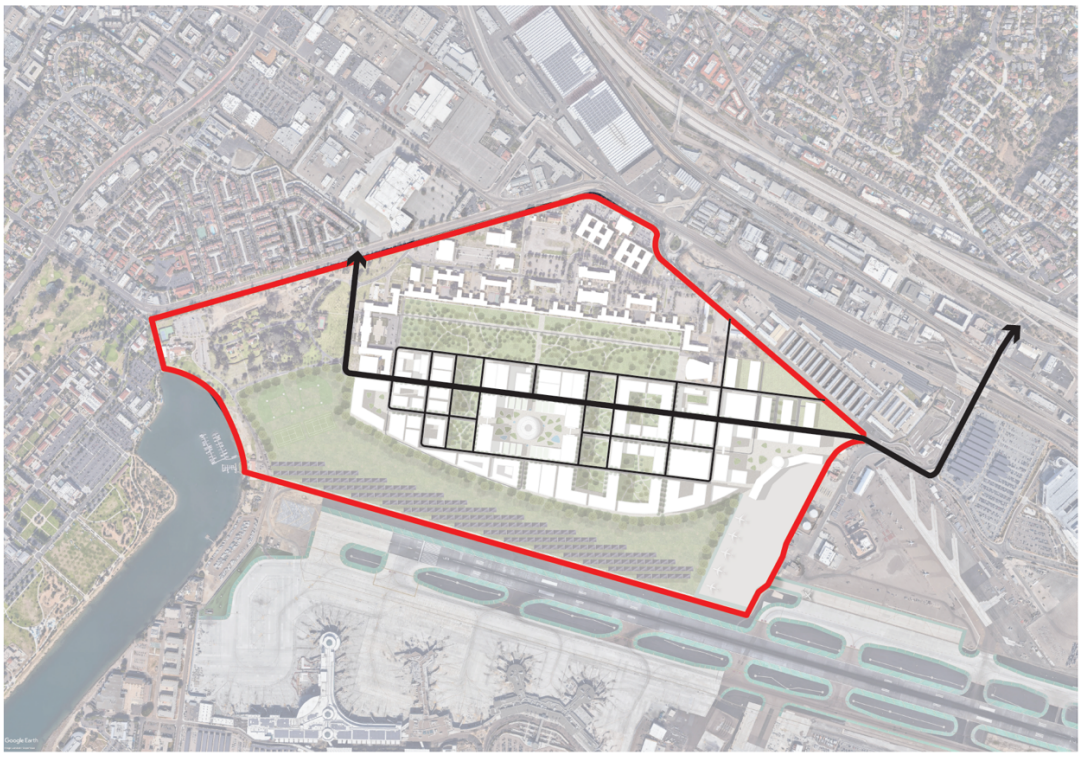

Fig 45: Transport System – Vehicular
(Source: Google Earth/Author)

Fig 46: Transport System – Rail
(Source: Google Earth/Author)

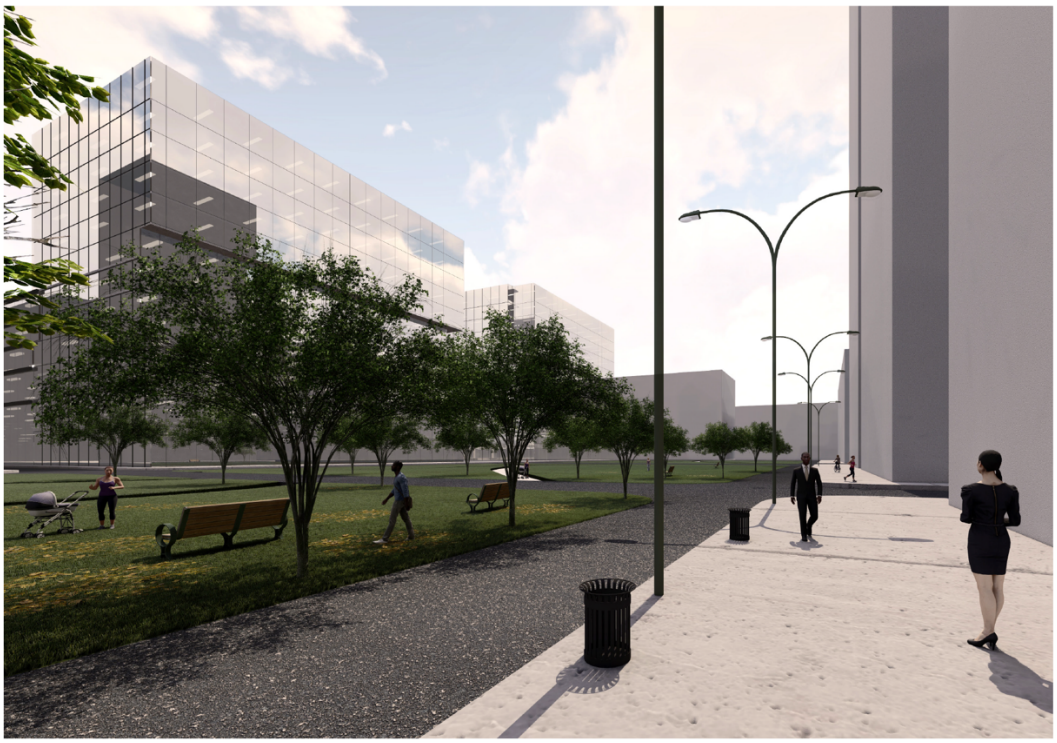

Fig 47: Street View Rendering – Park
(Source: Author)

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